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GENETICAL STUDIES ON GOLD-FISH OF JAPAN.

(Plates I–XII)

Yoshiichi Matsui

(Received Feb. 13. 1934)

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GENETICAL STUDIES ON GOLD-FISH OF JAPAN.

I. On the Varieties of Gold-fish and the Variations in Their External Characteristics.

Introduction

According to ancient records[1], gold-fish were imported into Japan from China in 1502 (the second year of Bunki) or in 1620 (the sixth year of Genna), but it is highly probable that they entered the country at various periods, after which they multiplied themselves. The original varieties seem to have been the Wakin, the Hibuna, and the Ranchû, according to old literature and Japanese pictures. Our knowledge of what transportation conditions were in those times support this supposition. About 1800 (in the years of Anyei and Temmei) the Ryûkin was imported, followed in the era of Meiji, by the Demekin. These have produced many varieties, some twenty in number, as the result of many years of breeding and selecting. They are classified, according to their histories, into the following forms:

1. Imported from China
   Wakin, Ranchû, Ryûkin, Demekin.
2. Varieties produced in this country
   a. Selected from prototypes
      Jikin, Nankin, Tosakin, Tetsu-wonaga, Osaka-ranchû, Hanafusa.
   b. Produced by crossing
      Watônai, Kinranshi, Shubunkin, Shûkin, Calico.
3. Origin obscure
   Oranda-shishi-gashira.

I have been studying and experimenting on the inheritance of fresh-water fish, especially gold-fish and carp, since 1914, and excepting the Hanafusa, have propagated all sorts of Japanese gold-fish to the number of over a million. This paper gives the results of my studies during those years. In investigating external characters, I have, in many of my experiments, used 100 fish of like age and environment. And in

computation of variations I have used the following formulas:

Mean value (M) $= \frac{\Sigma p.v}{n}$, Probable error (p.e.) $= \pm 0.6745 \times \frac{\sigma}{\sqrt{n}}$

Standard deviation $(\sigma) = \sqrt{\frac{\Sigma p\alpha^2}{n}}$, p.e. $= \pm 0.6745 \times \frac{\sigma}{\sqrt{2n}}$

Coefficient of variation (V) $= \frac{100\sigma}{M}$, p.e. $= \pm 0.6745 \times \frac{V}{\sqrt{2n}} \sqrt{1+2\left(\frac{V}{100}\right)^2}$

It is my pleasant duty to acknowledge most gratefully the invaluable suggestions I have received from the late Dr. Kametaro Toyama and the late Mr. Kichigoro Akiyama; from Professor Kiichi Miyake and from Messrs. Tadashi Higurashi, Saki Hoshino, and Mikusa Tokuhisa. I wish also to express my sincere thanks to Mr. A. Kumada for valuable work done in photographing and to Messrs. T. Kaneko, T. Watanuki, T. Takai, Y. Muramatsu, I. Ando, S. Arita, M. Matsuda, T. Kato, and H. Kono for indispensable aid rendered in connection with breeding, sketching, taking measurements, and in the computations.

I. Varieties of Japanese Gold-fish.

1. The Wakin.

The body is rather slender for a gold-fish, and the fins are short. The variation in the external characters is best seen in Table 1. Certain differences exist in the sexes.

The caudal fins are classified into 'Yotsu-wo' (tetra-lobed tail), 'Mitsu-wo' (tri-lobed tail), 'Sakura-wo' (form intermediate between tetra and tri-lobed tail), and 'Funa-wo' (simple lobed tail), the first two being the commonest.

The anal fins are classified into single fin and double fin; and rarely the V-shaped and the Y-shaped fins, which are intermediate forms of the single and double fins, although in rare cases some fish lack their anal fins. But as these characteristic forms of fins are not fixed, it is difficult to find a pure race on the market. The selection of their forms in breeding is very difficult, for although their 'Hiraki-wo' (paired caudal fin include Yotsu-wo, etc.) seem to have come from the 'Funa-wo' by recessive mutation, they are of very unstable nature, often showing reverse mutation, some examples of which are given in Table 2.

Table 1.

	Frequency		Mode		Mean value		Standard deviation		Coefficient of variation	
	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀
Body length. / Body height.	2.2～2.7	2.1～2.6	2.4	2.4	2.4051± 0.0109	2.3639± 0.0095	±0.1011± 0.0077	±0.1102± 0.0067	4.2036± 0.3210%	4.6618± 0.2847%
Body length. / Body width.	4.0～5.3	3.9～5.2	4.5～5.0	4.5～5.0	4.6090± 0.0366	4.5205± 0.0288	±0.3387± 0.0259	±0.3336± 0.0204	7.3487± 0.5612%	7.3797± 0.4506%
Caudal fin length. / Body length.	0.19～0.33	0.19～0.32	0.25～0.30	0.25～0.30	0.2660± 0.0035	0.2578± 0.0027	±0.0321± 0.0025	±0.0314± 0.0019	12.0677± 0.9350%	12.1800± 0.7547%
Body length. / Eye diameter.	13.1～19.2	13.1～20.1	15.1～16.0	15.1～18.0	15.9615± 0.1143	16.3525± 0.1326	±1.0585± 0.0808	±1.4580± 0.0890	6.6316± 0.5065%	8.9161± 0.5447%
Number of scales on lateral line.	27～31	27～31	29	29	29.2564± 0.1086	29.1311± 0.0725	±1.0056± 0.0768	±0.8391± 0.0512	3.4372± 0.2625%	2.8804± 0.1759%
Number of scales in transverse series.	6～7/8～10	6～8/8～10	6/9	6/9	15.3333± 0.0747	15.4260± 0.0595	±0.6918± 0.0528	±0.6885± 0.0420	4.5117± 0.3446%	4.4632± 0.2725%
Number of rays in dorsal fin.	16～20	15～21	18	17	17.6154± 0.0935	17.5901± 0.0943	±0.8657± 0.0661	±1.0921± 0.0667	4.9144± 0.3753%	6.2086± 0.3791%
Number of rays in pectoral fin.	13～18	13～18	16	16	15.6410± 0.1210	15.7213± 0.0953	±1.1206± 0.0856	±1.1034± 0.0674	7.1645± 0.5472%	7.0185± 0.4291%
Number of rays in ventral fin.	6～9	6～9	8	8	7.6923± 0.0555	7.8197± 0.0429	±0.5141± 0.0393	±0.4972± 0.0304	6.6833± 0.5104%	6.3583± 0.3833%
Number of rays in anal fin.	5～9	5～7	6	6	6.2308± 0.0712	6.2623± 0.0440	±0.6588± 0.0503	±0.5090± 0.0311	10.5733± 0.8165%	8.1280± 0.4963%
Number of rays in caudal fin.	32～41	32～43	37	38	37.2820± 0.1862	37.3443± 0.1539	±1.7239± 0.1317	±1.7823± 0.1038	4.6239± 0.3531%	4.7726± 0.2914%

Table 2.

Offspring of tetra-lobe tail and double anal fin, self-breeding.

Caudal fin / Anal fin	Tetra-lobe		Tri-lobe		Imperfect pair		Simple		Total	
Double	576	23.74%	1377	56.76%	46	1.90%	4	0,16%	2003	82.56%
Single	66	2.72%	286	11.79%	33	1.36%	7	0.29%	392	16.16%
Y shape	2	0.08%	11	0.45%	0	—	0	—	13	0.54%
V shape	2	0.08%	12	0.49%	3	0.12%	0	—	17	0.70%
No	0	—	0	—	0	—	1	0.04%	1	0.04%
Total	646	26.63%	1686	69.50%	82	3.38%	12	0.49%	2426	100%

Table 3.

Offspring of Funa-wo and single anal fin, self-breeding.

Caudal fin / Anal fin	Tetra-lobe		Tri-lobe		Imperfect pair		Simple		Total	
Double	34	1.88%	110	6.08%	175	9.68%	1	0.06%	320	17.70%
Single	61	3.37%	177	9.79%	176	9.73%	1070	59.18%	1484	82.08%
No	0	—	0	—	0	—	4	0.22%	4	0.22%
Total	95	5.25%	287	15.87%	351	19.41%	1075	59.46%	1808	100%

The scales are cycloid, the normal ones having iridocyst layers, but in the spring of 1927, I obtained some mutants[2] with net-like transparent scales, which I have been raising ever since.

The body colour of the young is brownish blue-black (iron colour), but as the fish grows, de-colouration begins and the colour changes into yellow, orange, white, or orange-white piebald. De-colouration, which is a characteristic phenomenon with gold-fish, seems to begin in different ways according to the condition of the fish and their environment. On scales that have once de-coloured, black pigment is often deposited again, which finally changes into deep black, but this seems to be a pathological change.

Some examples of de-colouration are shown in the following Table. Some fish began de-colouration when they were about 50 days old, while others did so more than 120 days later.

Table 4.

Number of days after hatching	Iron colour	De-colouring	Orange	Piebald	White	Total	Sum up	Decoloured %
65	520	451	46	179	26	1222	1222	20.54%
75	329	276	96	213	46	960	1211	46.66%
100	11	3	240	299	11	564	1170	98.80%
170	0	0						100%

The following Table shows that young fish whose parents are quite different from those in Table 4, although with the same environments, display differences in their de-colouration.

Table 5.

Number of days after hatching	Iron colour	De-colouring	Orange	Piebald	White	Total	Sum up	Decoloured %
85	621	183	662	798	162	2426	2426	66.86%
100	325	274	169	25	7	830	2412	75.17%
147	291	54	222	26	0	593	2406	85.66%
170	141	35	132	10	2	320	2381	92.61%

2. The Hibuna.

The form of the body is laterally flat and somewhat long. The caudal fin is short and almost Funa-wo, which makes it difficult to distinguish it from the Funa-wo of the Wakin. In some districts Wakin with Funa-wo are identified with Hibuna, but the latter's body colour is generally paler than that of the former, and shows de-colouration just as does the Wakin, only the start is much later than of the gold fish, in some Hibuna it being as late as the third year since hatching.

The form of the caudal fin and the body colour of the Hibuna 70 days after birth are shown in Table 6.

Table 6.

Caudal fin / Anal fin / Body colour	Simple tail				Paired tail				Total	
	Double		Single		Double		Single			
Iron colour	11	1.63%	610	90.24%	11	1.63%	25	3.70%	657	97.19%
De-colouring	0	—	14	2.07%	0	—	0	—	14	2.07%
Orange	0	—	5	0.74%	0	—	0	—	5	0.74%
Total	11	1.63%	629	93.05%	11	1.63%	25	3.70%	676	100%
	640		94.67%		36		5.33%			

3. Ryûkin.

The body is short and somewhat high. All the fins are long. This race is sometimes called the ' Onaga ' (long tailed) or ' Nagasaki.'

The caudal fin is long, some being veil-like ; the paired tail, such as in the Yotsu-wo and Mitsu-wo are common, but some fish have Funa-wo, hence often called ' Fukinagashi ' (streamer). This is identical with Mr. Innes' ' Nymph '[3].

As in the Wakin, there is no fixity in the form of the fins. The following Table shows variability of the fins.

Table 8.

Caudal fin / Anal fin	Tetra-lobe		Tri-lobe		Imperfect pair		Simple		Total	
Double	642	52.75%	269	22.10%	2	0.16%	1	0.08%	914	75.10%
Single	184	15.12%	89	7.31%	9	0.74%	1	0.08%	283	23.25%
Y shape	8	0.66%	4	0.33%	0	—	0	—	12	0.99%
V shape	1	0.08%	2	0.16%	1	0.08%	0	—	4	0.33%
No	3	0.25%	0	—	1	0.08%	0	—	4	0.33%
Total	838	68.86%	364	29.91%	13	1.07%	2	0.16%	1217	100%

The body has the same colour as that of the Wakin, which it resembles in the matter of de-colouring, the exception being the lateness of its start.

Table 7.

	Frequency		Mode		Mean value		Standard deviation		Coefficient of variation	
	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀
Body length. / Body height.	1.4～1.8	1.3～1.8	1.6	1.5	1.5733± 0.0107	1.5127± 0.0104	±0.1063± 0.0076	±0.1145± 0.0074	6.7565± 0.4804%	7.5692± 0.4868%
Body length. / Body width.	2.0～3.7	2.0～3.7	2.8	2.7	2.7833± 0.0373	2.5591± 0.0294	±0.3712± 0.0264	±0.3231± 0.0208	13.3367± 0.9649%	12.6255± 0.8249%
Caudal fin length. / Body length.	0.65～1.06	0.57～1.06	0.75～0.80	0.75～0.85	0.8294± 0.0098	0.7677± 0.0076	±0.0981± 0.0069	±0.0839± 0.0054	11.8321± 0.1286%	10.9287± 0.7028%
Body length. / Eye diameter.	8.0～13.3	8.4～12.9	9.1～10.0	10.1～11.0	9.8778± 0.1147	10.3727± 0.1012	±1.1409± 0.0811	±1.1128± 0.0716	11.5501± 0.8321%	10.7282± 0.0547%
Number of scales on lateral line.	24～29	25～29	27	27	27.0000± 0.1038	27.3636± 0.0971	±1.0328± 0.0734	±1.0679± 0.0687	3.8252± 0.2720%	3.9026± 0.2510%
Number of scales in transverse series.	5～7/8～10	5～7/8～10	6/9	6/9	15.3778± 0.0907	15.5636± 0.0710	±0.9016± 0.0641	±0.7807± 0.0502	5.8630± 0.4169%	5.0162± 0.3226%
Number of rays in dorsal fin.	14～19	14～18	16	16	16.3556± 0.0998	16.1818± 0.0696	±0.9923± 0.0706	±0.7650± 0.0492	6.0670± 0.4313%	4.7275± 0.3041%
Number of rays in pectoral fin.	14～18	13～19	16	16	16.0000± 0.0874	15.9891± 0.1004	±0.8692± 0.0618	±1.1039± 0.0710	5.4325± 0.3812%	6.9041± 0.4440%
Number of rays in ventral fin.	6～9	7～10	9	8	8.0667± 0.0843	8.2909± 0.0664	±0.8431± 0.0599	±0.7304± 0.0470	10.4519± 0.7512%	8.8097± 0.5666%
Number of rays in anal fin.	5～8	5～8	6	6	6.1778± 0.0572	6.1818± 0.0428	±0.5692± 0.0405	±0.4707± 0.0303	9.2136± 0.6551%	7.6143± 0.4897%
Number of rays in caudal fin.	28～40	28～40	38	38	36.3111± 0.2947	35.3818± 0.2788	±2.9313± 0.2084	±3.0659± 0.1972	8.0727± 0.5740%	8.6652± 0.5573%

Table 9.

Number of days after hatching.	Iron colour	De-colouring	Orange	Piebald	White	Total	Sum up	Decoloured %
70	1156	87	64	56	22	1385	1385	10.25%
75	982	145	24	54	6	1211	1353	16.70%
80	422	346	156	184	8	1109	1301	40.97%
110	82	151	281	184	8	706	1243	81.26%
130	35	76	91	4	0	206	1216	99.55%

The head is small, and the tip of the mouth is commonly pointed. Sometimes, although rarely, we find some with a warty growth on the head, which however is not so prominent as that of the Ranchû or the Oranda-shishi-gashira.

4. The Ranchû. (Maruko).

The body is short, broad, and roundish. This race has no dorsal fin; the other fins are short. It has another name 'Chôsen' or 'Maruko', one of the earliest race of which seems to have come from China, as shown in old pictures and mentioned in old literature.

There are three varieties of this race, the prototype of which, though not raised generally at present, often appears under certain conditions of breeding.

a. *The Ranchû.*

The head is large, with a warty excrescence, which is, as I have once reported,[5] an abnormal growth of the cuticle of the head, and for which the cranium has been developed specially to secure good cohesion. The excrescence has three sections, the cranial, the infraorbital, and the opercular, which according to the degree of development of each of three sections, is divided into three varieties:—

1. The 'Shishigashira' (lion-head), in which the three sections are equally developed.
2. The 'Tokin' (capped or hooded), in which the cranial part alone is developed.
3. The 'Okame' (swollen-cheeked), in which the infraorbital and opercular parts are developed.

Generally the growth of the warty excrescence is visible to the naked

eye about 120 days after hatching, its development depending upon the manner of rearing, that is, in most carefully attending to the food and the quality and temperature of the water. The best developed excrescence is covered, except on the lower jaw, with some small, round, blister-like prominences of diameters of from 0.5 to 1.5 mm., and having the appearance of strawberries.

The Ranchû characteristically lacks its dorsal fin, but the lacking character is not so fixed, so that even fish that are the product of long selections for the dozens of generations beget only 40% of good young with no dorsal fin. The appearance of the intermediate types is shown in Table 10, and Fig. 1 (Pl. I).

The body colour shows de-colouration, some changing into simple orange or white, and others into spotted colours of the same. Some have a rim-like colouration round every scale. The body rarely has that scarlet colour of a Wakin or a Ryûkin, but they sometimes reflect the sun's rays and glitter like gold.

Table 10.

	No dorsal finned		No dorsal finned but uneven		Rudimentary dorsal finned		Perfect dorsal finned		Total
No. 1	44	8.63%	49	9.61%	406	79.61%	11	2.16%	510
No. 2	72	41.14%	77	40.00%	21	12.00%	5	2.86%	175
No. 3	62	31.96%	119	61.34%	13	6.70%	0	—	194

Table 11.

	Frequency		Mode		Mean value	
	♂	♀	♂	♀	♂	♀
Body length. / Body height.	1.3~2.1	1.5~2.0	1.7	1.7	1.7207±0.0153	1.6762±0.0142
Body length. / Body width.	2.0~3.3	2.1~3.0	2.7~2.8	2.5	2.6466±0.0314	2.5119±0.0260
Caudal fin length. / Body length.	0.29~0.46		0.30~0.40		0.3505±0.0028	
Number of scales on lateral line.	23~29		26		26.1400±0.0787	
Number of scales in transverse series.	3~4/6~7		3/6		9.4800±0.0363	

Table 11. continued.

	Standard deviation		Coefficient of variation	
	♂	♀	♂	♀
Body length. / Body height.	±0.1729±0 0107	±0.1364±0.0100	10.0482±0.6302%	8.1375±0.5989%
Body length. / Body width.	±0.3546±0.0220	±0.2497±0.0184	13.3983±0.8463%	9.9287±0.7307%
Caudal fin length. / Body length.	±0.0413±0.0197		11.7832±0.5698%	
Number of scales on lateral line.	±1.1664±0.0556		4.4621±0.2128%	
Number of scales in transverse series.	±0.5381±0.0257		5.6762±0.2707%	

b. *The Osaka-Ranchû.*

The head, without any warty excrescence, is small and pointed at the tip of the mouth. The body being roundish, this variety is also known by the name of 'Maruko' (round-bodied). The caudal fin, which is paired and short, is almost perpendicular to the body-axis, which position causes the fish to oscillate greatly from right to left while swimming. The character of lacking the dorsal fin, like in the Ranchû, is unstable. Table 12 shows some examples of these that were begotten by parents of standard type.

Table 12.

No dorsal finned		No dorsal finned but uneven		Rudimentary dorsal finned		Total
105	11.72%	173	19.31%	618	68.97%	896

c. *The Nankin.*

This is a variety raised exclusively in the province of Izumo, and is very close to the prototype of the Ranchû. The head, which is small, with no warty excrescence, is pointed at the tip of the mouth. The abdominal region is swollen at the rear. The caudal fin is in ordinary position with reference to the body-axis, and has a paired tail.

The standard body colour is what is called 'Roku-rin', that is, red at the tip of the mouth on the opercular part and on every fin, and white on all other parts of the body. This colour arrangement is considered worthy of selection, but so far no artificial colour scheme has yet been attempted.

The character of lacking the dorsal fin is as in the Ranchû.

5. The Demekin. (Telescope-eyed gold-fish).

The body is somewhat short, and the fins, which originally were short, have lately become longer. The caudal fin is of the paired form.

The eyes, which are big and projecting have shapes either like pears, cylinders, water bubbles, or even something like telescopes pointed heavenward. These characteristic eyes are what have developed from the stage of intermediate growth, projecting themselves gradually one month after hatching, the speed with which it does so depending on the individuality of the fish. Table 13 shows some examples.

Table 13.

Number of days after hatching	Telescope eyed		Normal eyed		Total
30	0	—	898	100%	898
40	103	11.51%	792	88.49%	895
61	663	75.43%	216	24.57%	879
96	758	97.43%	20	2.57%	778
142	350	100%	0	—	350

Table 14.

	Frequency	Mode	Mean value	Standard deviation	Coefficient of variation
Body length. / Body height.	1.5~2.3	2.0	1.9810±0.0097	±0.1442±0.0069	7.2792±0.3472%
Caudal fin length. / Body length.	0.36~0.72	0.44~0.54	0.5035±0.0051	±0.0760±0.0036	15.0943±0.7361%
Body length. / Eye diameter.	5.3~9.3	7.0	6.8200±0.0547	±0.8109±0.0387	11.8900±0.5711%

The fish of this race have ordinary scales, although some varieties have transparent scales without iridocyst layers. They may be classified into the following three varieties.

a. *The Aka-demekin.* (Red telescope-eyed gold-fish).

These have ordinary scales, and like ordinary gold-fish, show decolouration, changing from iron-colour to orange, etc.

b. *The Kuro-demekin.* (Black telescope-eyed gold-fish).

These have ordinary scales, which, when not de-coloured, look very smoky black, the black pigment being prominently deposited in the cuticle. This begins to appear, like the de-colouration, 60 days after hatching, and at its best shows variation in its intensity. De-colouration in some of them begins when they are old, the change being to orange. The body colour of this variety varies from iron to blackish-brown and to smoky-black.

Table 15.

Number of days after hatching	Iron coloured		Black		Total
40	347	100%	0	—	347
60	130	38.24%	210	61.76%	340
80	24	7.10%	314	92.90%	338

c. *The Sanshoku-demekin.* (Calico telescope-eyed gold-fish).

These have mosaically transparent scales—the transparent scales being interposed mosaically amongst the ordinary scales. The scale character of this race is a mosaic hybrid between the transparent-scaled character and the normal-scaled one, and we find upon in-breeding that it always segregates the all transparent-scaled fish, the mosaic transparent-scaled, and the normal-scaled in the ratio of 1 : 2 : 1. The fish with the all transparent scales are somewhat difficult to rear, and do not exist nowadays as a pure variety.

The body colour does not show distinct de-colouration as in normal-scaled gold-fish, while there are many that produce only a very few melanophore even when the scales begin to grow about a month after hatching, so that, without showing any iron-colouration, they gradually develop into other colours, usually some mottled colour of red, yellow, blue, violet, white, etc., mingled with black spots, and sometimes a very complex colour according to the degree intensity of any of the above colours. In some we find the body lacking the black spots altogether, and in others either colourless or so pale that it is possible to see through the opercula into the colour of blood of the branchiae, and the eye-balls sometimes being black from lack of the iridocyst layer in the iris. The following Table shows the classification of the body colouration of the offspring

from mottled coloured parents.

Table 16.

Scale	Mottled colour		Orange and white piebald		Orange		White		Iron		Black		Total	
		%		%		%		%		%		%		%
Transparent	364	41.65	135	15.45	0	—	133	15.22	19	2.17	0	—	651	74.49
Normal	0	—	0	—	48	5.49	12	1.37	43	4.92	120	13.73	223	25.51
Total	364	41.65	135	15.45	48	5.49	145	16.59	62	7.09	120	13.73	874	100

The above-mentioned three varieties of Demekin are the common telescope-eyed gold-fish, which were first imported from Kwantung China, in the 28th year of Meiji (1895), and which since then have been reared and multiplied in this country.

d. *The Chôtengan.* (Astronomical telescope-eyed gold-fish).

This is also called ' Deme-ranchû ', an appellation first given by Dr. Mitsukuri (1904)[10] when some 30 of these fish were imported from Kwantung, China in the 35th or 36th year of Meiji (1902 or 1903). The name of ' Deme-ranchû ' has been mistaken by Mr. Smith (1917)[21] for a hybrid of Demekin and Ranchû, but the hybrid is not yet a variety. The axis of the telescope eyes point upwards, being turned round some 90 degrees, thus presenting a characteristic appearance. The development coefficient of this eyed character is lower than that of the common telescope-eyed ones, that of the standard type of this variety being some 30%, and is what may be seen 120 days after hatching.

The body is rather long and so are the fins, although the dorsal ones are lacking. The character of lacking the dorsal fin is more stable than in that of the Ranchû, being about 60%.

6. The Jikin.[11]

This race, which is also called ' Jiô ', ' Ji-kingyo ', ' Shachi ', and ' Kujaku ', is raised chiefly in Aichi Prefecture.

The body is slightly compressed and swollen in the abdominal region. The fins are short, the caudal one having a characteristic form called ' Kujaku-wo ' (peacock tail); and being X-shaped, has in the middle a broad part with some small scales, the tail therefore being almost perpendicular to the body-axis. The Kujaku-wo is appearently hereditary, but

its appearence coefficient is only 40% or so even in the typical kinds that underwent selection for from 50 to 60 generations.

Table 17.

Caudal fin / Anal fin	Kujaku		Tetra-lobed		Tri-lobed		Imperfect paired		Simple		Total	
Double	274	36.48%	326	43.41%	0	—	108	14.38%	11	1.46%	719	95.74%
Single	0	—	5	0.67%	0	—	17	2.26%	6	0.80%	31	4.13%
V-shape	0	—	0	—	4	0.53%	0	—	0	—	1	0.13%
Total	274	36.48%	331	44.08%	4	0.53%	125	16.64%	17	2.26%	751	100%

The standard body colour of this fish is red on the tip of the mouth and on the fins and white on the other parts of the body, which is called ' Rokurin ', but as this colouring is very rare, the use of artificial colouring matter is frequently resorted to, which operation however should be done before de-colouration begins by purposely injuring the cuticle and thus destroying the chromatophores. Table 18 shows the results of observations on the body colours of offspring begotten by parents with standard colours. The standard colour is absent in the offspring.

Table 18.

Number of days after hatching	Orange	White	Orange & white	Iron	De-colouration	Total	De-coloured %
70	9	45	40	454	58	606	15.51%
180	51	205	96	18	30	400	88.00%

7. The Tosa-kin. (Gold-fish of Tosa).

This is a race that is raised in Kôchi city and neighbourhood. It is very like the Ryûkin, but its fins are a little shorter, and the caudal fin is greatly extended on both sides, its outer rim being upturned. I once obtained this kind[4] and ascertained its hereditary character. It seems to me that the Tosa-kin is a result of long breeding and selection of the mutant derived from the Ryûkin, but the standard type appeared only to the extent of 30%.

8. The Tetsu-wonaga. (Iron-coloured long tail gold-fish).

This is the name for a kind of Ryûkin having a special body colour that appeared in reverse mutation. While most of them have no decolouration, there are however some that have it in a certain way, as shown in Table 19; in others it begins only in old age. In short, this is a very unstable race of gold-fish.

Table 19.

Iron coloured		Orange coloured		Total
120	72.73%	45	27.27%	165

9. The Oranda-shishi-gashira.

The body is short but a little longer than that of a Ryûkin; the fins are long, the caudal fin being a paired tail, many of which are veil-like. The head is large with a hood-shaped warty excrescense on the top (Tokin type of excrescence). The excrescence develops slower than in the Ranchû, that is, it becomes perceptible a few months later after the hatching, complete development being attained in the second year.

Table 20.

	Frequency		Mode		Mean value	
	♂	♀	♂	♀	♂	♀
Body length. / Body height.	1.5～2.0	1.3～2.0	1.7	1.6	1.7188±0.0097	1.6323±0.0108
Caudal fin length. / Body length.	0.48～0.80	0.48～0.87	0.61～0.65	0.56～0.60	0.6141±0.0059	0.5976±0.0108

	Standard deviation		Coefficient of variation	
	♂	♀	♂	♀
Body length. / Body height.	±0.1196±0.0069	±0.0896±0.0077	6.9583±0.3995%	5.4892±0.4702%
Caudal fin length. / Body length.	±0.0720±0.0041	±0.0888±0.0076	11.7245±0.0198%	14.8594±0.0338%

The body colour, like that of the Ryûkin, is a simple colour or dapple. As to the origin of this race, Dr. Mitsukuri (1914)[10] held that it is a hybrid of the Ryûkin and the Ranchû. But my experiments have shown that, while the warty excrescence is inherited as a recessive, the length of the caudal fin is inherited as an intermediate hybrid, so that in the hybrid of Ryûkin and Ranchû, the caudal fin ought to be shorter than that of the Ryûkin. This Oranda-shishi-gashira had a very long tail and did not segregate a short tail in their offspring. In the case of hybrids, as shown in Table 21, the dorsal fin is totally lacking or often incomplete, while in the next generation they segregated themselves in a complex manner, being unstable in character. But in the Oranda-shishi-gashira, no variation showed itself in the type of the dorsal. On the other hand, some Ryûkin begot a warty excrescence. I am therefore inclined to think that the Oranda-shishi-gashira is a mutant of the Ryûkin, and not the hybrid of a Ryûkin and a Ranchû.

Table 21.

Dorsal fin of the hybrid of Ryûkin and Ranchû.

No dorsal finned		Rudimentary dorsal finned		Perfect dorsal finned		Total
68	6.54%	760	72.11%	226	21.44%	1054

10. The Hanafusa.

According to Dr. Chen (1925),[12] there is in China a kind of gold-fish called 'Narial Bouquet', whose narial septum is greatly swollen into a ball shape. In Japan a very similar type of gold-fish called 'Hanafusa' used to be raised at the times in the province of Ise up to some fourty years ago, which I suppose, is a variety of the Oranda-shishi-gashira, but with its warty excrescence undeveloped and its narial septum specially swollen like a ball.

11. The Watônai. (Waryû).[23]

According to Mr. Matsubara (1908),[9] this race seems to have been produced by crossing the Wakin with the Ryûkin, before the 16th year of Meiji (1883).

This race has the body form of the Wakin, with fins closely resembling those of the Ryûkin. I made experiments to prove that the F_1

from the crossing of the Wakin with the Ryûkin all produced this type of fish.

12. The Shûkin.

This is a product of selection of hybrids of the Ranchû and the Oranda-shishi-gashira. It lacks the dorsal fins of the latter. In the 30th year of Meiji (1897) Mr. Matsubara gave the race this name for the family name of Mr. Kichigoro Akiyama. It has not, however, been acknowledged as a fixed race, and has meanwhile become extinct. I have made experiments by which the fish of this kind could be produced by crossing the above-mentioned two races, as shown in Table 22, but the standard type appeared with a frequency of only 3.21%.

Table 22.

No dorsal finned		No dorsal finned but uneven		Rudimentary dorsal finned		Perfect dorsal finned		Total
22	3.21%	36	5.25%	569	82.94%	59	8.60%	686

13. The Kinranshi.

According to Mr. Matsubara (1908)[9], this was the name he gave in the 35th year of Meiji (1902) to what had been produced by Mr. K. Akiyama in crossing the Ranchû with the Ryûkin, about one-third of the offspring lacking their dorsal fins. But no further case of breeding has been reported since. From the picture drawn by Mr. Matsubara we can conclude that this race greatly resembles the Wakin, lacking only the dorsal fin. From my experiments, however, I obtained some fish of this type by crossing Wakin with Ranchû, and proved that crossing Ryûkin with Ranchû results in some progeny with long fins, and in the next generation with those having long fins as well as those with short. I therefore consider it a mistake to regard the Kinranshi as a hybrid of Ryûkin and Ranchû.

The colours shown in Mr. Matsubara's picture seem to be those of decolouring. In my own case, the body colour of this race, like that of Ranchû, is a simple orange or a dapple of orange and white, many of the scales glittering like gold, reflecting the sunlight in a peculiar way.

14. The Shubunkin.

This was obtained by Mr. K. Akiyama in the 33rd year of Meiji (1900),

and named by Mr. Matsubara. Akiyama, according to his paper (1912),[13] obtained this mixed race by crossing the Calico-demekin, the Wakin, and the Hibuna. The fish has mosaic transparent scales, normal eyes, long Funa-wo, and a mottled colour. But the results of my experiments show that there was no necessity for using the Wakin, since it had no effect at all. I obtained this race easily by crossing Calico-demekin with Funa. In other words, the Calico-demekin is a heterozygote in the scaled character, and since as shown in my other report,[8] it is a mosaic hybrid between the all transparent-scaled character and the normal-scaled character, when crossed with the Funa the progeny consists of fish normal-scaled and mosaic transparent-scaled in the ratio of 1 : 1, the latter being mottle coloured. But on crossing them with de-coloured gold-fish, the progeny consisted of many fish with no mottley coloured character. Since the telescope-eyed character moreover is recessive against the normal-eyed character, in the case of Funa, which have some inhibiting factors, it appears in the next generation in the ratio of 15 (normal-eyed) : 1 (telescope-eyed), but in the case of gold-fish alone, it appears with a ratio of 3 : 1.[7] As to the caudal fin, the Funa-wo of Funa is dominant over the paired tail of gold-fish, the length being an intermediate hybrid of long and short characters.[14] From the above-mentioned factor, it is only natural that many crossed offspring of Calico-demekin and Funa should have the characteristic of the Shubunkin.

Some examples of offspring begotten by parent of the standard type of this race are shown in Table 23.

Table 23.

Eye	Normal																Total	
Caudal fin	Long. 2633 (73.06%)								Short. 971 (26.94%)									
	Paired 186 (5.16%)				Simple 2447 (67.90%)				Paired 175 (4.85%)				Simple 796 (22.09%)					
Anal fin	Double		Single		Double		Single		Double		Single		Double		Single			
		%		%		%		%		%		%		%		%		%
Transparent scale.	96	2.66	30	0.83	23	0.64	1767	49.03	103	2.86	40	1.14	11	0.31	524	14.54	2595	72.00
Normal scale.	43	1.20	17	0.47	5	0.14	652	18.09	24	0.67	7	0.19	3	0.08	258	7.16	1009	28.00
Total	139	3.86	47	1.30	28	0.78	2419	67.12	127	3.53	47	1.33	14	0.39	782	21.70	3604	100

This means that rate of appearance of this race of the standard type is 49.67%, including in it many fish with mottled colours besides many with yellow-black dapples.

15. The Calico.

When the Calico-demekin is crossed with the Ryûkin, the Wakin, or the Oranda-shishi-gashira, etc., they produce offspring of mosaic transparent-scaled and normal-scaled in the ratio of 1 : 1, all being normal-eyed. The fish with transparent-scales is called Calico-ryûkin, Calico-wakin, Calico-oranda, etc. This name, it is said, was given by Mr. Franklin Packard, an American, in the 45th year of Meiji (1912) for Mr. K. Akiyama's fish.

The body colour is mostly red-white dapples, mottled coloured being rare.

16. The Comet or Tetsugyo. (Iron-fish).

This gold-fish, belonging to the race that Mr. Innes (1917)[3] called 'Comet', has a long body, long fins, and simple tail. According to Dr. Hozawa (1927),[15] it greatly resembles a Japanese fish called 'Tetsugyo' (iron-fish). I obtained a similar kind of gold-fish in crossing Ryûkin with Funa, and also in their reciprocal crossing, and in breeding Shubunkin.

In the hybrid of Funa and long tailed gold-fish, e.g. Ryûkin, the simple tail and the single anal fin of Funa is dominant over the paired tail and double anal fin of gold-fish, the length of the fins being intermediate. The caudal fin of the hybrid therefore is longer than that of the Funa, and the long tail grows longer as it advances in age. These characteristics are easily found upon comparing Tables 24 and 25, when it will be seen that they correspond roughly with the results of Dr. Hozawa's studies[15] of Tetsugyo.

Table 24.

Variation in some characters of the hybrid of Ryûkin and Funa.

	Frequency	Mode	Mean value	Standard deviation	Coefficient of variation
Body length. / Body height.	2.1～2.7	2.3	2.3212±0.0092	±0.1264±0.0007	5.4454±0.2817%
Caudal fin length. / Body length.	0.37～0.48	0.40～0.45	0.4100±0.0010	±0.0825±0.0007	20.1219±1.7341%

Table 25.

Variation in the ratio of caudal fin length to body length.

Race	Frequency	Mode	Mean value	Standard deviation	Coefficient of variation	Remarks
(Ryûkin × Funa)F_1 fourth year.	0.44~0.68	0.46~0.50	0.5420± 0.0062	±0.0646± 0.0044	11.9188± 0.8153%	
Tetsugyo.	0.50~0.75	0.50~0.55	0.5817± 0.0014	±0.0792± 0.0009	13.6152± 1.7411%	from Dr. Hozawa's data

The body colour having a tendency to show a maternal inheritance, often shows de-colouration. The hybrid is very shy of man, just like Funa, its natural disposition resembling that of a Tetsugyo.

II. Variation in the External Characters of Japanese Gold-fish.

In the preceding chapter I described virtually all the races of Japanese gold-fish. In the present chapter I shall deal with variation in their external bodily characters in controst with those of Funa (crusian carp), the prototype of the gold-fish.

1. Bodily form.

I measured and compared the ratios of length to height, and the height to width, as shown in Tables 26, 27.

Table 26.

Variation in ratio of length to height.

Race	Frequency	Mode	Mean value	Standard deviation	Coefficient of variation
Funa	2.4~3.2	2.9	2.8900±0.0081	±0.1196±0.0057	4.1384±0.1974%
Wakin	2.1~2.7	2.4	2.3800±0.0079	±0.1168±0.0056	4.9076±0.2341%
Demekin	1.5~2.3	2.0	1.9810±0.0097	±0.1442±0.0069	7.2792±0.3472%
Ranchû	1.3~2.1	1.7	1.7020±0.0101	±0.1503±0.0072	8.8308±0.4212%
Oranda-shishi-gashira	1.3~2.0	1.7	1.6920±0.0087	±0.1295±0.0062	7.6537±0.3650%
Ryûkin	1.3~1.8	1.5	1.5400±0.0078	±0.1149±0.0055	7.4610±0.3558%

Table 27.

Variation in the ratios of body length to body width.

Race	Frequency	Mode	Mean value	Standard deviation	Coefficient of variation
Funa	4.2～6.5	5.5～6.0	5.6550±0.0307	±0.4552±0.0217	8.0495±0.3839%
Wakin	3.9～5.3	4.5～5.0	4.5550±0.0228	±0.3383±0.0161	7.4270±0.3542%
Ryûkin	2.0～3.7	2.5～3.0	2.6600±0.0245	±0.3632±0.0154	13.6541±0.6633%
Ranchû	2.0～3.3	2.5～3.0	2.5900±0.0218	±0.3231±0.0154	12.4749±0.6041%

2. Caudal fin.

The caudal fin of gold-fish present a great number of variations—the Funa-wo (simple tail), the Tsumami-wo (imperfect form of Mitsu-wo), the Mitsu-wo (tri-lobed tail), the Sakura-wo (shape intermediate between Mitsu-wo and Yotsu-wo), the Yotsu-wo (tetra-lobed tail), the Kujaku-wo (X-shaped tail), etc. And each of these has also its intermediate type, showing continuous variation and often producing various deformities. These types of caudal fins, excepting the Funa-wo, are called Hiraki-wo or paired tail.

Now the Hiraki-wo of a gold-fish is developed from branchings of the hypural bone,[17] and has some correlation with the double anal fins. The slightly swollen lower rim of the lower lobe of the Funa-wo is the first step in the change. A shallow groove next forms in the rim and then gradually deepens, after which the groove divides the lower lobe into a right and a left part. Finally the whole changes into a Tsumami-wo, and further dividing itself changes into a Mitsu-wo. A Mitsu-wo split slightly along its middle line is a Sakura-wo, so called from a fancied resemblance to the petal of a cherry flower, while that with a deeper split is a Yotsu-wo, and that with the deepest split is a Kujaku-wo.

Some apparently simple tails are really paired, that is to say, although they have the appearance of a simple tail, two lobes of a paired tail lie the one on the other. Some have both ends (the upper and lower) of their two lobes fixed together, and such tail is called ' Fukuro-wo ' (bag-shaped tail). That shown in Figs. 14, 15, 16, 17 (Pl. III), are a naturally paired tail that has been malformed into a simple tail. A ' Tsumami-wo ' has an upper and two lower lobes, but some forms have, conversely, two

upper and one lower lobe. Some 'Mitsu-wo' or 'Yotsu-wo' have a more characteristic lobe in the middle, making four or five lobes in all. Such type of tail is called 'Kaji-wo' (rudder shaped tail) (Figs. 18—20, Pl. III). Since the anal fin is also sometimes called a 'Kaji', we must distinguish it from the 'Kajiwo'. In a Ranchû we often find a sort of projection on the middle top of a Mitsu-wo.

The length of the caudal fin varies greatly, as shown in Table 28. Some of the long tails are veil-shaped. As in the case of the Jikin and the Osaka-ranchû, tails are almost at right angles to the body axis.

Table 28.

Variation in the ratio of the length of caudal fin to body length.

Race	Frequency	Mode	Mean value	Standard deviation	Coefficient of variation
Funa	0.23—0.32	0.27	0.2690±0.0141	±0.0218±0.0039	8.1040±0.3865%
Wakin	0.19—0.33	0.25—0.30	0.2610±0.0021	±0.0318±0.0015	12.0677±0.9350%
Ranchu	0.29—0.46	0.30—0.35	0.3505±0.0028	±0.0413±0.0197	11.7832±0.5698%
Demekin	0.36—0.72	0.46—0.55	0.5035±0.0051	±0.0760±0.0036	15.0943±0.7361%
Oranda-shishi-gashira	0.48—0.87	0.55—0.60	0.6090±0.0052	±0.0764±0.0036	12.5452±0.0556%
Ryûkin	0.57—1.06	0.75—0.85	0.7955±0.0085	±0.1261±0.0060	15.8510±0.1550%

Table 29.

Variation in the number of caudal fin rays.

Race	Frequency	Mode	Mean value	Standard deviation	Coefficient of variation
Funa	17—20	19	18.7900±0.0321	±0.4753±0.0227	2.5295±0.1206%
Wakin	32—43	38	37.3200±0.1187	±1.7600±0.0839	4.7160±0.2249%
Ryûkin	28—40	38	35.8000±0.2021	±2.9966±0.1429	8.3704±0.3992%

3. Anal fin.

Although the anal fin of ordinary fish is always single, in the gold-fish it is sometimes double, that is, some gold-fish have two anal fins, and especially in the case of a paired tail, we often find two anal fins showing some linkage between them, as I have mentioned in another paper.[14]

Between the single anal fin and the double fin are some intermediate types, the Y-shaped and V-shaped, the differences between them being in the degree of the continuous variation. The anal fin is often wanting, but this does not seem to be a hereditary character.

Table 30.

Variation in the anal fin rays.

Race	Frequency	Mode	Mean value	Standard deviation	Coefficient of variation
Funa	6	6	6.0000	—	—
Wakin	5~9	6	6.2500±0.0386	±0.5723±0.0273	9.1568±0.4367%
Ryukin	5~8	6	6.1800±0.0349	±0.5173±0.0247	8.3706±0.3992%

4. Dorsal fin.

Some gold-fish, such as the Ranchû and the Chôtengan, lack dorsal fins, but as this lacking character is not so stable in these races, there being also continuous intermediate types, we often find only slight projections in place of the dorsal fin. Whenever a fish lacks its dorsal fin, the interspinous bones will also be wanting, with the result that the vertebrae are sometimes fused together and curved. The pure sort of Ryûkin and Wakin often lack their dorsal fins. Table 31 shows some example of Ryûkin.

Table 31.

Perfect dorsal finned		Rudimentary dorsal finned		Total
1171	95.83%	51	4.17%	1222

Table 32.

Variation in the number of dorsal fin rays.

Race	Frequency	Mode	Mean value	Standard deviation	Coefficient of variation
Funa	14~18	17	17.1700±0.0540	±0.8007±0.0382	4.6634±0.2224%
Wakin	15~21	17~18	17.6000±0.0681	±1.0100±0.0482	5.7386±0.2737%
Ryûkin	14~19	16	16.2600±0.0593	±0.8789±0.0419	5.4053±0.2578%

5. Pectoral fin.

Table 33.

Variation in the number of pectoral fin rays.

Race	Frequency	Mode	Mean value	Standard deviation	Coefficient of variation
Funa	16～17	16	16.1700±0.0253	±0.3756±0.0179	2.3228±0.1108%
Wakin	13～18	16	15.6900±0.0769	±1.1396±0.0543	7.2632±0.3494%
Ryûkin	13～19	16	16.0100±0.0678	±1.0049±0.0479	6.2767±0.2994%

6. Ventral fin.

Table 34.

Variation in the number of ventral fin rays.

Race	Frequency	Mode	Mean value	Standard deviation	Coefficient of variation
Funa	8～9	9	8.9400±0.0160	±0.2375±0.0113	2.6566±0.1267%
Wakin	6～9	8	7.7700±0.0342	±0.5071±0.0242	6.5264±0.3113%
Ryûkin	6～10	9	8.2500±0.0526	±0.7794±0.0372	9.4473±0.4506%

7. Eyes.

The eyes of the gold-fish abound in varying characters, the telescope-eyed character involving the common telescope-eyed character and the Chôtengan (skyward telescope or astronomical telescope-eyed) character. To the former belong the pear-shaped, cylinder-shaped, bubble-shaped, etc. The degree of projection also varies while the diameters of the eye-

Table 35.

Race	Frequency	Mode	Mean value	Standard deviation	Coefficient of variation
Funa	8.1～17.9	13.0～14.0	13.3500±0.0892	±1.3219±0.0630	9.9019±0.4723%
Wakin	13.1～20.1	15.0～18.0	16.2000±0.0897	±1.3304±0.0635	8.2123±0.3917%
Ryûkin	8.0～13.3	9.0～10.0	10.1500±0.0777	±1.1522±0.0550	11.3517±0.5483%
Demekin	5.3～9.3	6.0～7.0	6.8200±0.0547	±0.8109±0.0387	11.8900±0.5711%

balls differ considerably. Table 35 shows the variation in the ratio of bodily length to the eye diameter.

The telescope-eyed character is inherited as recessive against the normal-eyed character.[7]

8. Scales.

The scales are all cycloids. Those lined with iridocyst layers on the reverse side are normal scales, those that lack them completely are transparent scales, while those in which the parts that lack them form a network are net-like transparent scales. Scale transparency varies in many ways in distribution; there being mosaic transparent and all transparent, the subject having been dealt with fully in another paper.[8]

According to Dr. Chen (1925),[12] in China are some gold-fish with hemispherical scales, called 'pearl scale' looking like the half of a pearl—a kind unheard of in Japan. He states that the colour of the pearl scales is prominent in its rim. Brilliant rims are also found in some kinds of Japanese gold-fish called 'Azuki Sarasa'. I have once seen a deformed gold-fish covered with scales arranged in reverse direction.

Table 36.

Variation in the number of scales in a lateral line.

Race	Frequency	Mode	Mean value	Standard deviation	Coefficient of variation
Funa	29~31	30	30.2500±0.0409	±0.6062±0.0289	2.0040±0.0956%
Wakin	27~31	29	29.1800±0.0614	±0.9097±0.0434	3.1175±0.1487%
Ranchû	23~29	26	26.1400±0.0787	±1.1664±0.0556	4.4621±0.2128%
Ryûkin	24~29	27	27.2000±0.0762	±1.1300±0.0539	4.1544±0.1981%

Table 37.

Variation in the number of scales in transverse series.

Race	Frequency	Mode	Mean value	Standard deviation	Coefficient of variation
Funa	4~6/5~6	5/6	10.5400±0.0551	±0.8176±0.0390	7.7571±0.3700%
Wakin	6~8/8~10	6/9	15.3900±0.0466	±0.6913±0.0330	4.4919±0.2142%
Ranchû	3~4/6~7	3/6	9.4800±0.0363	±0.5381±0.0257	5.6762±0.2707%
Ryûkin	6~7/8~10	6/9	15.4800±0.0568	±0.8424±0.0402	5.4419±0.2596%

The Ranchû has some small scales in place of the dorsal fin, and a noticeable character of this race is that it has a small number of scales in transverse series.

9. Sexual Characters.

The males have rather slender bodies and longer fins, as shown in the following Tables.

Table 38.

Ratio of body length to body height.

Race	♂	♀
Wakin	2.4051±0.0109	2.3639±0.0095
Ryûkin	1.5733±0.0107	1.5127±0.0104
Oranda	1.7188±0.0097	1.6323±0.0108
Ranchû	1.7207±0.0153	1.6762±0.0142

Table 39.

Ratio of length of caudal fin to body length.

Race	♂	♀
Wakin	0.2660±0.0035	0.2578±0.0027
Ryûkin	0.8294±0.0098	0.7677±0.0076
Oranda	0.6141±0.0059	0.5976±0.0108

The sexes of the gold-fish can be distinguished by examining their generative apertures, which are elliptic, smaller, and project slightly more in the males than in the females. As to the secondary sexual characters, the males have pearl organs, which grow on the pectoral fins and the opercula or sometimes on the dorsal fin, ventral fins or scales during the breeding season, and when the fish are in the second year of their growth, and even on the caudal fin when most highly developed sexually. The pearl organ disappears after breeding, but sometimes reappears during the breeding season, and also sometimes when properly nourished, several times every 10 days. The time of breeding is influenced by the tempera-

ture of the water, the range of favourable temperature being from 12°C to 30°C, about 20°C being the optimum.

The pearl organs rarely appear in the female. I have observed[16] the following nine cases in which the organs were not so prominent.

Table 40.

Race	Years	Body length	Number of pearl organs and places of their appearance			
			Left side		Right side	
			Operculum	Pectoral fin	Operculum	Pectoral fin
Ryûkin	3	7.2 c.m.	0	6	2	11
Ryûkin	3	7.3 〃	0	9	0	10
Calico-ryûkin	4	9.0 〃	0	0	0	3
(Demekin × Wakin) F_1	5	10.1 〃	0	12	0	11
〃	5	7.3 〃	0	0	0	8
〃	5	7.2 〃	0	5	0	5
(Ryûkin × Funa) F_1	5	6.8 〃	2	10	3	11
〃	5	7.4 〃	3	6	4	4
〃	5	6.9 〃	1	0	1	2

The ratio of males to females does not vary much in the races, being something like 1 : 1, as shown in Table 41. The males, with their longer and finer fins are more beautiful than the females, and are inclined to have a greater number of fancier's fish after surviving repeated selections.

Table 41.

Race	♂	♀	Total	Males per 100 females
Wakin	685	679	1364	100.88
Ryûkin	876	883	1759	99.21
Ranchû	115	109	224	105.50
Demekin	768	763	1531	100.66
Oranda	258	243	501	106.17

III. On the Genealogy of the Japanese Gold-fish.

Having been man's pet for so many years, the gold-fish have produced not a small number of mutants from time to time. We can thus see that after much multiplication through repeated artificial selection, these mutants have become established races of the present. Even in my own experiments for only about twenty years, I have obtained some mutants, from which it may be infered that the gold-fish has very changeable characters.

The gold-fish is commonly believed to be a variety of the Funa (Carassius carassius (L.),[22] to prove which Ishihara and Misao (1929)[13] studied the question experimentally and ascertained the existance of a close relationship between the Funa and the gold-fish, based upon the precipitation reaction of the serum of the two.

With the object of studying this relationship by means of cross-breedings, I tried, as shown in Table 42, crossing gold-fish with Funa and with carp, (the bodily form of the latter being supposed to approach nearest to that of a Funa), and in every cases I obtained normal hybrids. But in the hybrids of the carp with gold-fish and Funa, the spermatozoa of the males, owing to some abnormal spermatogenesis, were not ejected. This male sterility, that I found was duly reported at the time.[19] Between the various races of the gold-fish such an abnormal condition does not exist, and this suggests some relationship among the three—the gold-fish have closer kinship with the Funa than with the carp, which kinship corresponds with the similarity in form of the three species.

Table 42.

Crossing	Breeding activity	Crossing	Breeding activity
Funa × Carp	Male sterile	Wakin × Funa	Normal
Carp × Funa	〃	Funa × Demekin	〃
Ryûkin × Carp	〃	Demekin × Funa	〃
Yellow carp × Ryûkin	〃	Jikin × Funa	〃
Funa × Ryûkin	Normal	Funa × Jikin	〃
Ryûkin × Funa	〃	Ranchû × Funa	〃
Funa × Wakin	〃	Funa × Ranchû	〃

In systematic zoology the carp belongs to the genus Cyprinus and the Funa to the Carassius, both belonging to the family Cyprinidae; the distinction between these two genera being that the former has two pairs of barbels in the mouth part, the pharyngeal teeth having the dental formula 1, 1, 3, while the latter has no barbels, having the dental formula 4.

In the gold-fish, which have the characteristics of the Carassius, the Wakin with a Funa-wo and single anal fin (the most primitive type of the gold-fish) can not be distinguished, so far as form goes, from a Funa before decolouration. It is only in certain behaviours that a Funa differs from a gold-fish. In their reaction to man, for example, the former avoids him, darting madly away from him, whereas the latter on the contrary follow and pursue him.

The paired tail, which is the most prominent characteristic of the gold-fish, has continuous variation, from the Funa-wo (simple tail) up to the complete paired one, which clearly shows that the paired tail is the transformation of a simple tail. The results of my experiments on heredity also show that paired tails are begotten in recessive mutation, and having an unstable character, are apt to cause reverse mutation.

The body colour, which is the second prominent characteristic of the gold-fish, in early age is similar to that of the Funa, and sometimes, as in the Tetsu-wonaga, does not de-colourize. On the other hand, the Hibuna show de-colouration. In other fish also, transformation of body colour is not rare, e.g., the red carp, white carp, yellow carp, albino carp[20], likewise the wild catfish, loach, eel, etc., which often change into red or white.

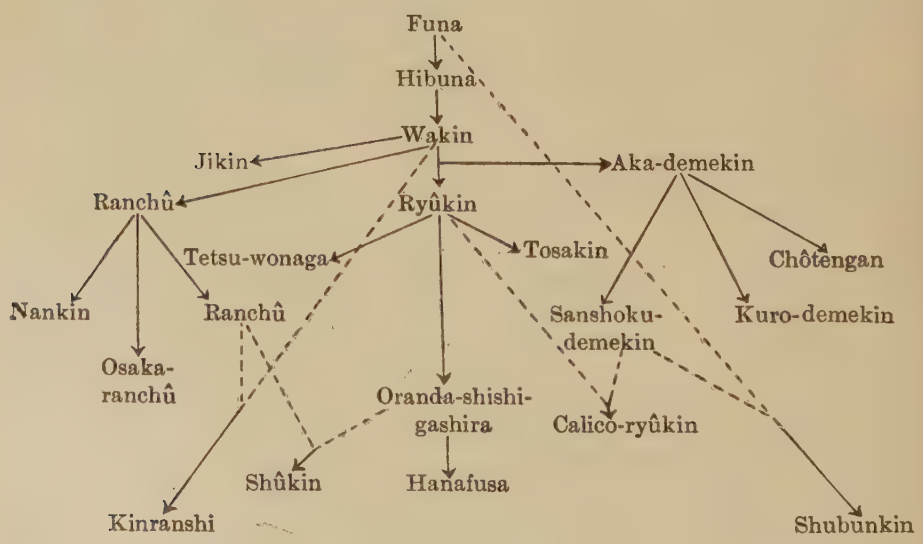
As I have mentioned in the previous chapter, the variations in the characteristics of each race of gold-fish have certain relations to those of Funa, showing a gradually increasing or decreasing variation, which enables us to witness the processes and the extent of the changes.

We must say that in the above-mentioned relationships found by means of the serum reaction and from the results of crossing, the similarity in bodily forms, etc., show clearly that the primitive type of gold-fish is a mutant of the Funa. It follows therefore that the prototype of the gold-fish is the Funa, the first step of the transformation of which seems to be the Hibuna, the Wakin being a race of gold-fish nearest to the prototype.

In the matter of transformations in the race of gold-fish, we find such changes as shortening of the bodily form, transformation or lengthening of the fins, plumpness of the skin covering the head, disappearance of the iridocyst layers in the scales, changes in colour, etc.

Now in considering these peculiarities more closely, we find it possible, seeing that the roots are clear, to trace the genealogy of the gold-fish begotten by crossing. In like manner we can follow up the clue along the various stages of variation in different kinds of gold-fish. For example, in the Wakin with their longer fins, it seems to have been necessary that their bodies should shorten in order to maintain the balance of their bodies, which resulted in a race of Ryûkin. When the reverse mutation occurred in the body colours of the Ryûkin the Tetsu-wonaga race resulted. The Oranda-shishi-gashira seem to be a variety of the Ryûkin with warty excrescence on the head especially developed. When the paired Yotsu-wo of a Wakin develops by opening itself rather widely, it is called a Kujaku-wo, and a gold-fish with such a tail we call Jikin. Lacking the dorsal fin, which is often a characteristic in the Wakin, begets a primitive type of Ranchû, while from the Ranchû we get such races as the Nakin, the Osaka-ranchû, etc. As a type intermediate between the Wakin and the Ryûkin, we have fish with a projecting eyed character, such as the Aka-demekin. From the last race we have the Kuro-demekin and the Sanshoku-demekin, which have transparent scales and which are the product of a dominant mutation, while in the Chôtengan the dorsal fin has been lost and the position of

Table 43.

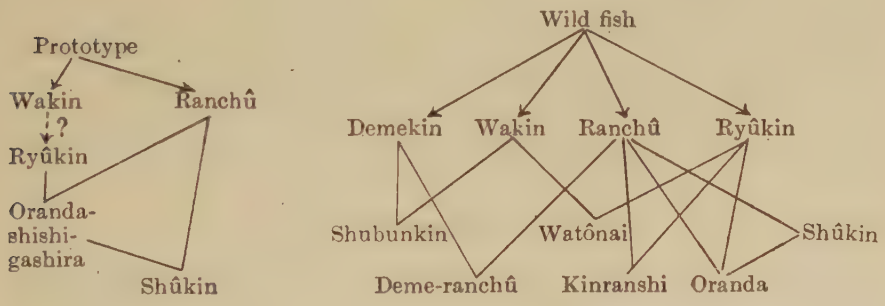


its eye-balls has changed. I have constructed the above diagram showing the lineage of the races of gold-fish, according to my experiments. (Table 43, Plate VI).

Of the studies so far published on the genealogy of gold-fish, the important are those by Dr. Watase (1887),[17] by Dr. Mitsukuri (1904),[11] and by Mr. Smith (1917)[21].

Dr. Watase believes the Wakin to be the prototype from which have arisen the Ryûkin and the Maruko (Ranchû). Dr. Mitsukuri seems to have acknowledged, though with certain reservations, that the Wakin and the Ranchû have homologically developed from a wild species. He also thinks that the Oranda-shishi-gashira is a hybrid of the Ryûkin and the Ranchû. Mr. Smith is of the opinion that the Wakin, the Ryûkin, and the Demekin have all been descended from a wild species, and regards the origin of the Oranda-shishi-gashira in the same way as does Dr. Mitsukuri. He also believes the Deme-ranchû (also called Chôtengan) to be a hybrid of the Demekin and the Ranchû, and the Shubunkin to be a hybrid of the Wakin and the Demekin. The opinions of these two investigators are shown diagrammatically as follows:

Table 44.



(by Mitsukuri) (by Smith)

Dr. Watase has discussed exclusively the Wakin, the Ryûkin, and the Maruko, and I share his opinions. Of my objection to Dr. Mitsukuri's contention that the Oranda-shishi-gashira is the hybrid of the Ryûkin and the Ranchû, I have already explained in the previous chapter. I can no more agree with the opinion that the Wakin and the Ranchû have homologically come down from the prototype than I can endorse Mr. Smith's view, to which I shall next refer.

Mr. Smith thinks all the Demekin, the Wakin, the Ranchû, and the Ryûkin to be varieties directly and homologically developed from the prototype, an opinion to which I cannot subscribe; for it is not natural that more than two quite different characteristics should be produced directly from a wild species. It must be much easier and more natural that one characteristic should have been produced first, followed by another change, and then another, and so on, which I think it quite reasonable in view of the result of experiments. In other words, it is more natural that first the simple tail should have changed into a paired one, thus producing the Wakin which is a variety nearest to the prototype, followed by the appearance of those varieties with long paired tail, with telescope eyes, or without dorsal fin, than that the wild species should have produced at once many varieties such as those with paired, telescope eyed, long tail, or without dorsal fin.

On the other hand my view is supported by the fact that, nowadays in the breeding and selection of whatsoever race of gold-fish, the processes of development above mentioned can be witnessed from time to time.

Furthermore, it is quite speculative to theorize that in the hybrids, the Shubunkin will be produced from the Wakin and the Demekin, and the Deme-ranchû from the Demekin and the Ranchû. The latter mistake arose through a wrong picture in Mr. Matsubara's paper,[9] and the association of the name of Deme-ranchû. Seeing that in discussing the origin of the various races of gold-fish, I have already explained the error of the view that the Ranchû and the Ryûkin beget the Kinranshi and the Oranda-shishi-gashira, I shall refrain from commenting further on the subject.

Summary

1. As existing races of Japanese gold-fish we have the Wakin, the Ryûkin, the Ranchû, the Osaka-ranchû, the Nankin, the Aka-demekin, the Kuro-demekin, the Sanshoku-demekin, the Chôtengan, the Jikin, the Tosakin, the Tetsu-wonaga, and the Oranda-shishi-gashira. As hybrids we have the Watonai, the Shubunkin, the Calico, the Shûkin, the Kinranshi, and the Comet. And as a race now extinct, I may mention the Hanafusa. In the present paper I have explained the aspects and characteristics of each of these races.

2. As to the bodily form of Japanese gold-fish, the ratio of body length to height is from 1.3 to 2.7, that of the Funa being 2.4 to 3.2. The

caudal fin is classified into the Funa-wo and the Kujaku-wo, the intermediate types forming a continuous variation. The ratio of length of tail to body length is from 1.06 to 0.14. The anal fin varies from single to double, the intermediate types constituting a continuous variation. The dorsal fin also shows a continuous variation between having it and lacking it. The eyes are classified into normal eyes and telescope eyes, the ratio of body length to eye-diameter being from 20.1 to 5.3. The scales are the ordinary ones, the transparent ones, and the net-like transparent ones, the number of scales on the lateral line (the Ranchû has the smallest number) being from 23 to 31, which is fewer than that of the Funa.

The males of gold-fish have their bodies more slender and their fins longer than those of the females. The pearl organs, which are secondary sexual characters of the male, appear however, although very rarely, in the female as well. The numbers of males and females are about the same.

3. The variation in the external characters of every race of gold-fish begins with variation in those of the Funa as a basis, with gradually increasing or decreasing frequency. In the caudal fin, the anal fin, and in the bodily colouration the most prominent morphological characteristics are intermediate types of the continuous variation between gold-fish and Funa, and every race of gold-fish produces a hybrid normally with the Funa, and the Wakin with simple tail, which before de-colouration, is indistinguishable from the Funa. These facts go to show that the Funa must be the prototype of the gold-fish. A Wakin with specially lengthened fins is a Ryûkin, and a mutant of Ryûkin with warty excrescence on the head is an Oranda-shishi-gashira. A Wakin with a Kujaku-wo is a Jikin, and if it has lost its dorsal fin, it is a Ranchû, while if its eyes become projected, it is a Demekin.

I have ascertained from the results of my experiments that the Kinranshi is the hybrid of a Wakin and a Ranchû, and that the Shubunkin is the hybrid of a Sanshoku-demekin and a Funa. I have thus proved the fallacy of the view that the Kinranshi is the product of crossing the Ryûkin with Ranchû, and the Shubunkin of crossing the Sanshoku-demekin with the Wakin, and the Oranda-shishi-gashira of crossing the Ryûkin with the Ranchû.

March, 1933.

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Explanation of the Figures. (Plate I–VI).

Fig. 1. Variation of lacking dorsal fin in Ranchû.
Fig. 2. Jikin.
Fig. 3. ,,
Fig. 4. Kujaku-wo.
Fig. 5. Tosakin.
Fig. 6. ,,
Fig. 7. (Ryukin × Wakin) F_1, mutant of overlaped caudal fin.
Fig. 8. ,,
Fig. 9. (Ryukin × Ranchu) F_1
Fig. 10. (Wakin × Ranchu) F_1
Fig. 11. (Demekin × Funa) F_1
Fig. 12. (Ryukin × Funa) F_1
Fig. 13. Forms of caudal fin, Funa-wo, Mizo-wo, Tsumami-wo, Mitsu-wo, Yotsu-wo.
Fig. 14. A form of Tsumami-wo.
Fig. 15. Funa-wo.
Fig. 16. Mizo-wo.
Fig. 17. Funa-wo with-groove.
Fig. 18. Kaji-wo.
Fig. 19. ,,
Fig. 20. ,,
Fig. 21. Fukuro-wo.
Fig. 22. Deformities of caudal fin.
Fig. 23. ,,
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Fig. 25. Deformity of caudal fin and imperfect dorsal fin in Wakin.
Fig. 26. Imperfect dorsal fin in Ryûkin.
Fig. 27. Imperfect dorsal fin in Wakin.
Fig. 28. Skeleton of Ranchû.
Fig. 29. ,,
Fig. 30. Anal finless in Wakin.
Fig. 31. Pearl organs in male of Wakin.
Fig. 32. Ovary and pearl organ in female of Ryûkin.
Fig. 33. (Ryûkin × Fuua) F_1, female pearl organ.
Fig. 34. ,,

Fig. 35. Funa.
Fig. 36. Hibuna.
Fig. 37. Wakin.
Fig. 38. Ryûkin.
Fig. 39. Jikin.
Fig. 40. Ranchû (Prototype of Ranchû).
Fig. 41. Nankin.
Fig. 42. Osaka-ranchû.
Fig. 43. Ranchû.
Fig. 44. Aka-demekin.
Fig. 45. Sanshoku-demekin.
Fig. 46. Kuro-demekin.
Fig. 47. Chôtengan (Deme-ranchû).
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Fig. 49. Tetsu-wonaga.
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Fig. 51. Hanafusa.
Fig. 52. Watonai.
Fig. 53. Kinranshi.
Fig. 54. Shûkin.
Fig. 55. Calico-ryûkin.
Fig. 56. Shubunkin.
Fig. 57. Tetsugyo.

PL. I.

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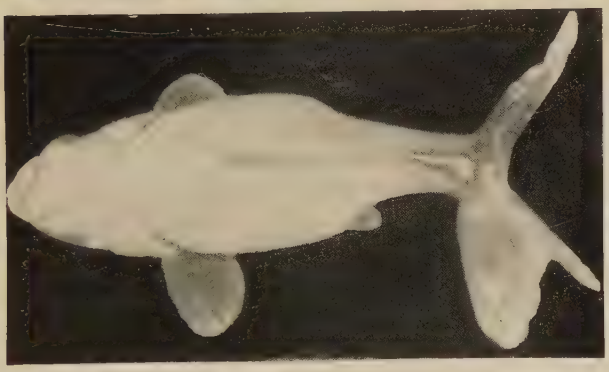

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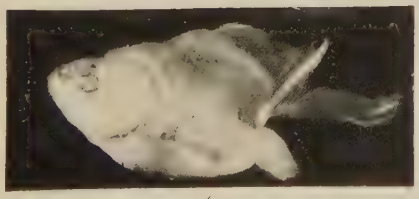

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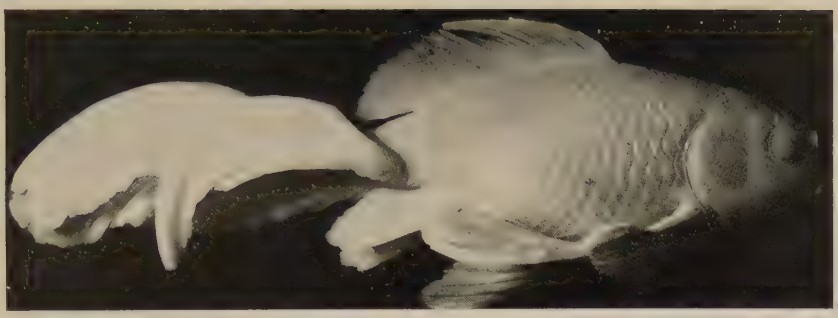
PL. II.



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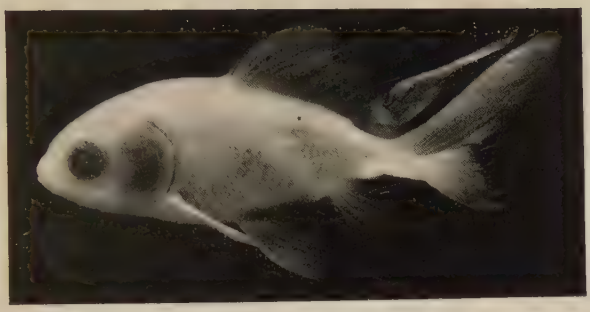

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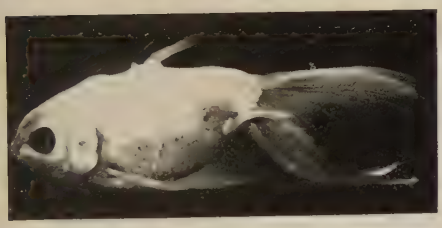

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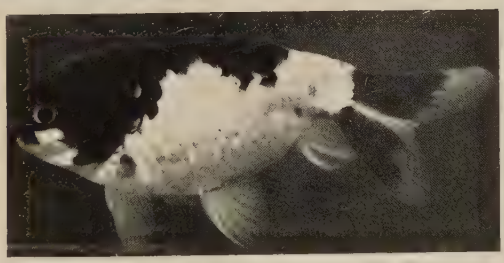

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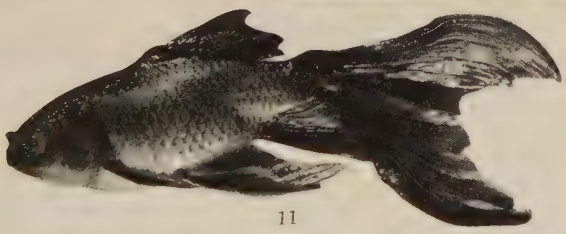

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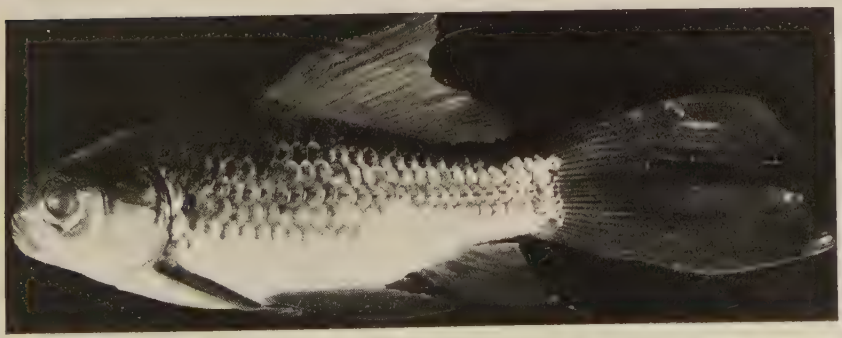

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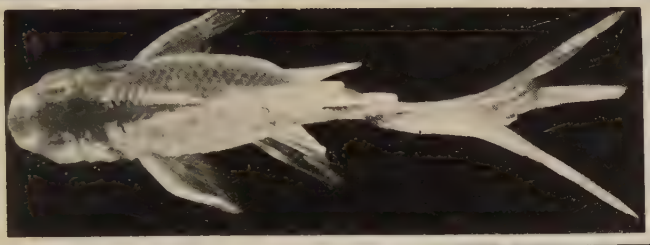

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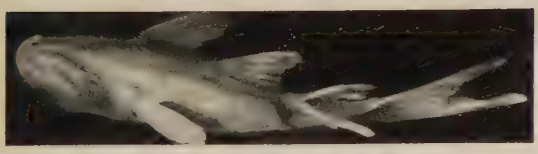

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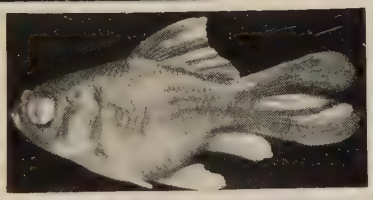

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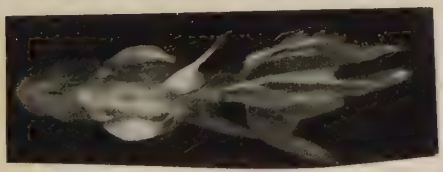

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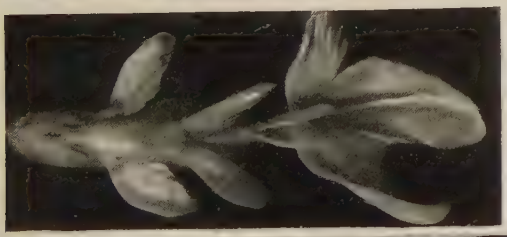

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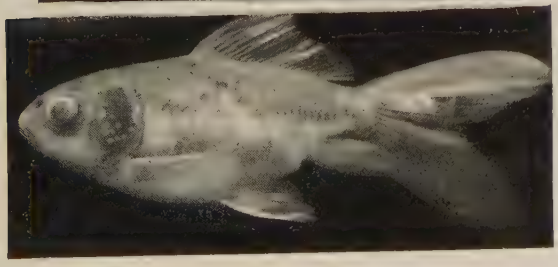

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PL. IV.

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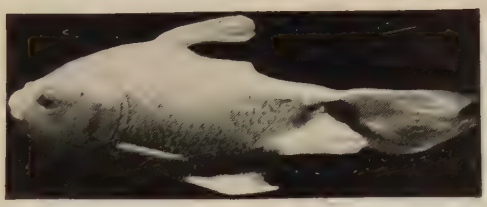

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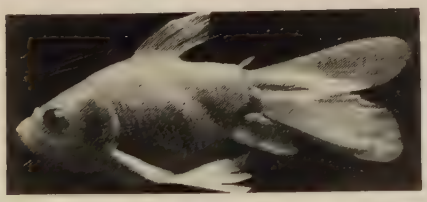

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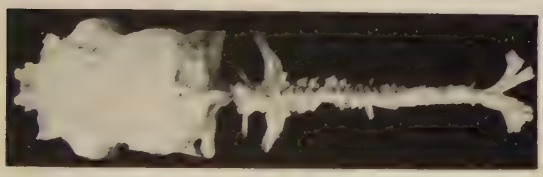

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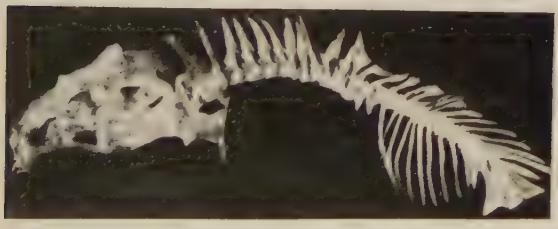

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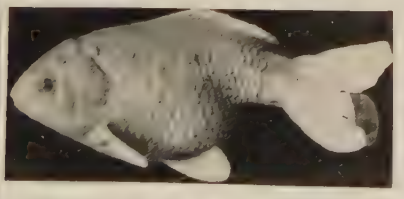

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PL. V.

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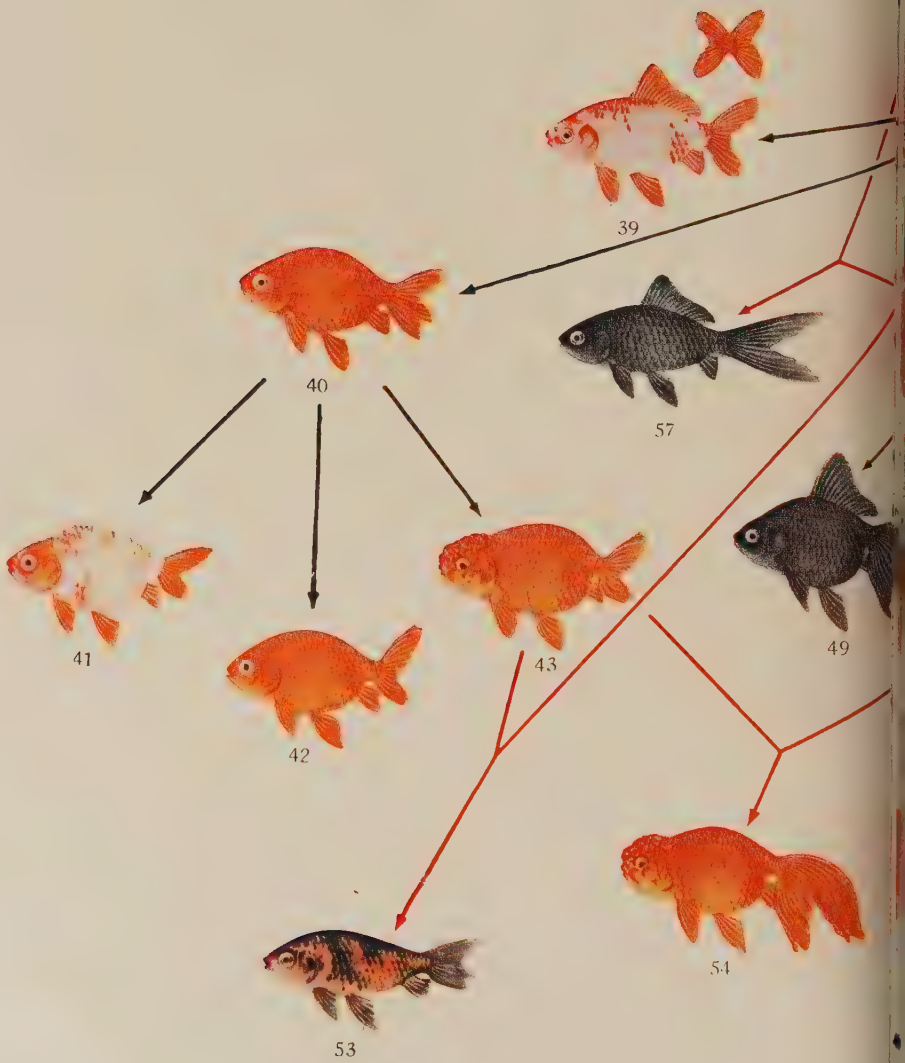
PL. VI.



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2. On the Mendelian Inheritance of the Telescope Eyes of Gold-fish.

(Plates VII, VIII)

Introduction

Among the large number of varieties of the gold-fish we find the so-called 'Telescope-eyed gold-fish', whose eyes are projected in a peculiar manner. These eyes begin to project themselves at various speeds two or three months after hatching. Some of them protrude at right angles to the body axis, while others turn upward after doing so. The latter kind is called the 'Astronomical Telescope Eyes'.[2] To the former belong the cylindrical form, the pear form, and the bubble form of eyes.

The inheritance of the eyes of gold-fish is a subject on which both Drs. C. Ishikawa and K. Toyama have experimented since 1900. It is my inexpressible regret, however, that neither of these investigators completed the work which they had begun. This I feel particularly in the case of Dr. Toyama, who was taken away at the time he was engaged on these studies.

I had been studying under the late Dr. Toyama since 1914, but since his death in 1918, I have been pursuing the same subject, alone, under the kind guidance of Professor K. Miyake, and this paper is the result of these studies. In it is incorporated a part of the late Dr. Toyama's unfinished investigations. The late Doctor's notes (1908–1917) on his experiments, which long had been missing since his death, were fortunately, after much laborious searching, found by his son.

It might be added here with reference to the inheritance of the telescope-eyed character of the gold-fish, that Mr. Higurashi (1914)[3] reported in his preliminary notes that the telescope-eyed character is recessive against the normal-eyed character. Dr. Berndt (1925)[4] published a similar report.

In these studies I am greatly indebted to the kindness of the late Dr.

K. Toyama, Prof. K. Miyake, Messrs. T. Higurashi, S. Hoshino, M. Tokuhisa, and the late K. Akiyama, and also to the indispensable assistance rendered by my assistants, Messrs. A. Kumada, T. Takai, I. Ando, M. Matsuda, and T. Watanuki. Thanks are also due to Mr. Kaneyasu Toyama, son of the late Doctor, who so kindly allowed me the use of his father's experimental notes.

Materials.

As material for investigating the telescope eyes I have made use of a number of Sanshoku-demekin, Aka-demekin, and Kuro-demekin, whose telescope-eyed characters were homozygous, although the rate at which the eyes projected themselves varied with the fish, some doing so after the second month from hatching, and others after a year from hatching. In this the fishes seem to be influenced to some extent by the state of their nutrition. The ratio of their body length to eye diameter is given in Table 1. For investigating the normal-eyed character, I have made use of a number of Ryûkin, Oranda-shishi-gashira, Wakin, Ranchû, and Funa. These fishes were all homozygotes with respect to the normal-eyed character. In this paper, the first two numerals in every number of the experiment show the date of the experiment, e. g., 0908 means that the experiment was made in 1909.

Table 1.

Race	Frequency	Mean value	Standard deviation	Coefficient of variation
Wakin	13.1~20.1	16.2000±0.0897	±1.3304±0.0635	8.2123±0.3917%
Ryûkin	8.0~13.3	10.1500±0.0777	±1.1522±0.0550	11.3517±0.5483%
Funa	8.1~17.9	13.3500±0.0892	±1.3219±0.0630	9.9019±0.4723%
Demekin	5.3~ 9.3	6.8200±0.0547	±0.8109±0.0387	11.8900±0.5711%

Experimental Results.

I. Experiments on the Telescope-Eyed Character of the Parent Fish.

From experiments on the telescope-eyed character of the parent fish, I found that there is some variation in speed in its appearance, but this was homozygous, as shown in Table 2.

Table 2.

Experiment No.	Parents	Number of offspring				Date of observation	Number of days after hatching	Investigator
		Telescope eye	Semi telescope eye	Normal eye.	Total			
0908	Demekin × Demekin	66	0	2	68	—	—	Toyama
0911	〃	67	0	0	67	—	—	〃
18043	Sanshoku-demekin × Sanshoku-demekin	663	0	216	879	20/VII	61	Matsui
〃	〃	758	0	20	778	4/IX	96	〃
〃	〃	350	0	0	350	20/XI	142	〃
1805	Kuro-demekin × Kuro-demekin	339	0	68	407	20/VII	78	〃
〃	〃	398	0	7	405	4/IX	113	〃
2204	Sanshoku-demekin × Aka-demekin	35	0	32	67	4/X	119	〃
〃	〃	50	0	13	63	3/XII	148	〃
2604	Kuro-demekin × Sanshoku-demekin	155	0	0	155	4/X	127	〃
2605	Sanshoku-demekin × Kuro-demekin	16	0	0	16	4/X	127	〃
2203	Kuro-demekin × Sanshoku-demekin	158	12	39	209	25/IX	83	〃
〃	〃	175	5	14	194	12/XII	161	〃
〃	〃	0	0	2	2	23/III'23	272	〃
2222	〃	170	13	67	250	25/IX	96	〃
〃	〃	229	16	4	249	25/XI	157	〃

The changes found in Exp. No. 2222 are shown in Table 3.

Table 3.

Number of days after hatching	Telescope eye	Semi-telescope eye	Normal eye
96	170	13	67
157	6	4	
	53	12	4
380		0	0

The Table shows that the semi-telescope eye is a step to the telescope eye.

II. Experiments on Crossing of Telescope eyes with Normal ones.

From crossings made, as shown in the following Table, it is apparent that the normal-eyed character is distinctly dominant over the telescope-eyed character.

Table 4.

Experiment No.	Parents	F_1			Investigator
		Normal eye	Telescope eye	Total	
0807	Sanshoku-demekin × Ranchû.	420	0	420	Toyama
0820	Ranchû × Demekin	24	0	24	〃
0912	Demekin × Oranda	302	0	302	〃
0915	Ryûkin × Demekin	40	0	40	〃
0921	Demekin × Wakin	33	0	33	〃
0922	Wakin × Demekin	399	0	399	〃
18041	Sanshoku-demekin × Wakin	1872	0	1872	Matsui
18042	Wakin × Sanshoku-demekin	2889	0	2889	〃
2206	Demekin × Wakin	364	0	364	〃
2311	Wakin × Demekin	14	0	14	〃
2213	Funa × Sanshoku-demekin	800	0	800	〃
2306	Sanshoku-demekin × Funa	97	0	97	〃
2601	〃	340	0	340	〃

III. Experiments on F_2 Generation.

Table 5.

Experiment No.	Parents	F_2					σ	$p.\varepsilon$	$\frac{\sigma}{p.\varepsilon}$	Investigator
		Normal eye	Ratio	Telescope eye	Ratio	Total				
1007	0807 F_1	36	3.0638	11	0.9362	47	±0.0638	±0.1704	0.37	Toyama
1012	0812 F_1	770	3.1237	216	0.8763	986	±0.1237	±0.0372	3.33	〃
〃	〃	67	3.0455	21	0.9545	88	±0.0455	±0.1245	0.37	〃
〃	〃	703	3.1314	195	0.8686	898	±0.1314	±0.0390	3.37	〃
21401	18041 F_1	120	3.0769	36	0.9231	156	±0.0769	±0.0935	0.82	Matsui
21403	〃	62	3.0244	20	0.9756	82	±0.0244	±0.1290	1.89	〃
2211	〃	94	3.1333	26	0.8667	120	±0.1333	±0.1067	1.25	〃
22402	18042 F_1	98	3.0154	32	0.9846	130	±0.0154	±0.1025	0.15	〃
2719	2206 F_1	222	3.0204	72	0.9796	294	±0.0204	±0.0681	0.30	〃
2927	〃	235	3.0519	73	0.9481	308	±0.0519	±0.0666	0.78	〃

It is clear that the smallness of the frequency in the appearance of the telescope eyes compared with that of normal eyes, is, as seen from experiments with the parent fish, caused by difference in the earliness with which the telescope-eyed character appears. These two eye characters were segregated in the ratio of 3 : 1. As to the F_2 of the crosses of the telescope-eyed gold-fish with the Funa, I made experiments as shown in the following Table and found that the telescope eyes appeared very slowly, only two fish with such eyes having been obtained, while their appearance in gold-fish more than 100 days old was very pronounced.

Table 6.

Exp. No.	Parents	Normal-eyed	Telescope-eyed	Total	Investigator
2503	2306 F_1	1698	0	1698	Matsui
2607	〃	926	0	926	〃
2608	〃	756	1	757	〃
2710	〃	451	0	451	〃
2801	2601 F_1	28	1	29	〃

Unfortunately most of these fish died from desease, so that I could not observe them as fully as I had wished. I could, however, perceive the slowness in the appearance of the telescope eyes, and that the segregation ratio was of quite a different type from the results of Table 5, as we shall see later in connection with experiments in back crossing. (Some fish developed their telescope eyes so late as in the fourth year of their hatching). The following Table shows the experiments on the F_3 of Exp. No. 2608 F_2. Here we do not find any appearing of telescope eyes before the fish are two years old.

Table 7.

Exp. No.	Parents	Normal-eyed	Telescope-eyed	Total
2919	2608 F_2	141	0	141
2920	〃	780	0	780
2921	〃	365	0	365
3014	〃	111	0	111
31001	〃	263	0	263

IV. Experiments in Back Crossing.

Table 8.

Exp. No.	Parents	F Normal eye	Ratio	F Telescope eye	Ratio	Total	σ	$p.\varepsilon.$	$\frac{\sigma}{p.\varepsilon.}$	Investigator
1	Ranchû × 0807 F_1	628	—	0	—	628	—	—	—	Toyama
2	0807 F_1 × Demekin	518	1.1372	393	0.8628	911	±0.1372	±0.0223	6.15	〃
3	Demekin × 0912 F_1	707	1.0306	665	0.9694	1372	±0.0306	±0.0182	1.68	〃
4	Demekin × 0820 F_1	49	1,1011	40	0.8989	89	±0.1011	±0.0715	1.41	〃
21410	18041 F_1 × Sanshoku-demekin	26	1.1304	20	0.8696	46	±0.1304	±0.0995	1.31	Matsui
2205	〃	97	1.1149	77	0.8851	174	±0.1149	±0.0511	2.25	〃
21413	〃	36	1.0909	30	0.9091	66	±0.0909	±0.0830	1.10	〃
21411	18041 F_1 × Kuro-demekin	347	1.1321	266	0.8679	613	±0.1321	±0.0272	4.86	〃
21405	〃	111	1.2686	64	0.7314	175	±0.2686	±0.0510	5.27	〃
21414	Sanshoku-demekin × 1804 F_1	19	1.0000	19	1.0000	38	±0.0000	±0.1094	0	〃
21409	〃	112	1.1089	90	0.8911	202	±0.1089	±0.0475	2.29	〃
21412	Aka-demekin × 1804 F_1	65	1.0400	60	0.9600	125	±0.0400	±0.0603	0.66	〃
2209	〃	115	0.1220	90	0.8780	205	±0.1220	±0.0471	2.59	〃
21407	1804 F_1 × Wakin	68	—	0	—	68	—	—	—	〃
21415	〃	90	—	0	—	90	—	—	—	〃
22407	〃	385	—	0	—	385	—	—	—	〃
21416	Wakin × 1804 F_1	155	—	0	—	155	—	—	—	〃

The progeny from crossing the telescope-eyed gold-fish with F_1 segregated the two eye characters in the ratio of 1 : 1, but in Exp. No. 2 (0807 F_1 × Demekin), $\frac{\sigma}{p.\varepsilon.}=6.15$, the deviation being greater than 5 times the probable error. This is due to the fact that owing to the early date of the observation, the appearance of the telescope eyes was slow. In Exp. No. 21405, in which the ratio of the normal-eyed character to the telescope-eyed character is 1 : 1, and $\frac{\sigma}{p.\varepsilon.}=5.27$, the ratio is beyond the possible limit. This is because, as shown in the following Table, the fre-

quency of the diameter of normal eyes varies greatly, the mean value being 7.8000, which is smaller than the mean value of the normal eyes in Nos. 21416 and 21413. This shows that the appearance of the telescope eyes from among the normal eyes was decidedly late, and that there were many eyes which ought to have changed into telescope eyes after the lapse of some more days.

Table 9.

Comparison of the ratio of eye-diameter of normal eye to body length in hybrid of normal-eyed fish and telescope-eyed.

Exp. No.	Parents	Frequency	Mean value	Standard deviation	Coefficient of variation
18042	Wakin × Demekin	8.8～11.7	9.9444±2.0535	±0.8315±1.4520	8.3615±1.3293%
21413	1804 F_1 × Demekin	7.2～11.7	9.1333±1.1247	±1.0796±0.7953	11.8204±1.0436%
21405	〃	5.3～12.3	7.8000±0.6288	±1.0916±0.4446	13.9948±0.8133%
21409	Demekin × 1804 F_1	5.8～11.3	7.8906±0.6653	±1.1808±0.4704	14.9646±0.9120%
21414	〃	8.0～11.7	9.5000±0.1163	±0.7746±0.0826	8.1537±0.8696%
21416	Wakin × 1804 F_1	7.5～13.3	9.0059±0.6589	±1.2235±0.4659	13.5855±0.7157%

Table 10.

Comparison of the ratio of eye-diameter of telescope eye to body length in hybrid of normal-eyed fish and telescope-eyed one.

Exp. No.	Parents	Frequency	Mean value	Standard deviation	Coefficient of variation
21413	1804 F_1 × Demekin	5.0～8.4	6.5000±1.5501	±1.0000±1.0961	15.3846±2.6549%
21405	〃	4.3～7.4	5.4333±0.6691	±0.7271±0.4731	13.3823±1.1872%
21409	Demekin × 1804 F_1	3.8～7.7	5.2293±0.7694	±0.8625±0.5315	16.4999±1.7229%
21414	〃	4.5～7.4	6.0333±1.0507	±0.9568±0.7430	15.8587±2.0014%

Every back crossed normal eye produced normal eyes. In the case of the F_1 of Demekin and Funa back crossed with Demekin, the segregation of the two eye characters were in the ratio of 3 : 1, as shown in the following Table. This is different from the case of the gold-fish alone, and may be called the special segregation of a dihybrid.

Table 11.

Experiment No.	Parents	F				Total	σ	$p.\varepsilon.$	$\frac{\sigma}{p.\varepsilon.}$
		Normal eye	Ratio	Telescope eye	Ratio				
2709	2306 F_1 × Funa	460	—	0	—	460	—	—	—
2706	〃	62	—	0	—	62	—	—	—
2708	2306 F_1 × Sanshoku-demekin	185	3.1092	53	0.8908	238	±0.1092	±0.0757	1.44
2930	Kuro-demekin × 2601 F_1	208	2.8299	86	1.1701	294	±0.1701	±0.0681	2.50
31002	Sanshoku-demekin × 2601 F_1	54	2.9189	20	1.0811	74	±0.0811	±0.1358	0.60

General Discussion.

Judging from the results of the above-mentioned experiments, it is clear that the telescope-eyed character is recessive against the normal-eyed character, and is inherited as monohybrid. The telescope eyes appear after the fish attains a certain period of growth, and varies in the time that it takes to appear.

Now since the telescope-eyed character arises out of the normal-eyed one, and is recessive, by adopting the gene symbol according to the system of Morgan, the normal-eyed character will then be *D* and the telescope-eyed one *d*, whence the genic constitution of these two characters are

Normal-eyed character *DD*, Telescope-eyed character *dd*,

so that the cross of the Sanshoku-demekin with the Wakin is the cross of *dd* with *DD*, the gametic combination being $dd \times DD = DDdd$, and this begets normal eyes. In F_2, $(D+d)^2 = 1\,DD + 2\,Dd + 1\,dd$, and the segregation of the normal and telescope eyes is 3 : 1. This agrees with the back cross, which segregates in the ratio 1 : 1.

In the case of crossings with Funa, the manner of appearance of the telescope-eyed character differs from that of the case of crossings with gold-fish. This is probably because the Funa have some inhibiting factors. If now we call the inhibiting factor, *A*, the constitution of the gene will be as follows :

Normal-eyed character of Funa *DDAA*

Telescope-eyed character of gold-fish *ddaa*

In other words, the cross of these characters is $DA \times da = DdAa$. In F_2, $(DA+Da+dA+da)^2 = 1\ DDAA + 2\ DDAa + 1\ DDaa + 2\ DdAA + 4\ DdAa + 2\ Ddaa + 1\ ddAA + 2\ ddAa + 1\ ddaa$, and since the phenotype is normal-eyed character 15, the ratio of these two eye characters is 15 : 1. In the back cross, $(DA+Da+dA+da) \times da = DdAa + Ddaa + ddAa + ddaa$, and, since the phenotype is normal-eyed character 3, the segregation ratio of the two is 3 : 1, which agrees with Exp. Nos. 2708, 2930, and 31002 (Table 11). These facts explain that, although the Shubunkin, which is the result of crossing the Sanshoku-demekin with the Funa, segregates various types in scale character and in caudal fin chracter, the eye character is almost fixed, so that in this race the appearance of the telescope-eyed character is rare compared with that of the normal-eyed character.

Summary.

1. The rate at which the telescope-eyed character makes its appearance varies in time.

2. The telescope-eyed character is recessive against the normal-eyed one, and these two characters are inherited as a Mendelian monohybrid. The gene for the normal-eyed character is represented by *D* and that for the telescope-eyed by *d*.

3. In the cross of the telescope-eyed character of gold-fish with the normal-eyed character of Funa, the latter has inhibiting gene *A*. In F_2, the normal-eyed character and the telescope-eyed character appear in the ratio of 15 : 1, but the latter character appears very slowly.

March, 1933.

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Explanation of Figures. (Plates VII, VIII).

Fig. 1. Development of telescope eyes.
Fig. 2. "
Fig. 3. (Demekin × Funa) F_1
Fig. 4. (Demekin × Ryûkin) F_1
Fig. 5. "
Fig. 6. (Demekin × Funa) F_1 × Demekin
Fig. 7. "
Fig. 8. Wakin (normal eye)
Fig. 9. "
Fig. 10. Sanshoku-demekin (telescope eye)
Fig. 11. "
Fig. 12. (Demekin × Funa) F_1

PL. VII.

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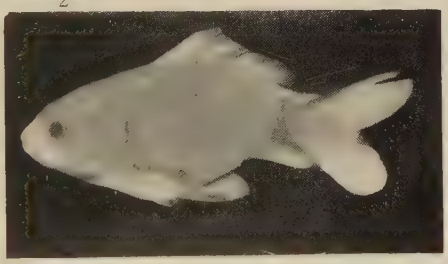

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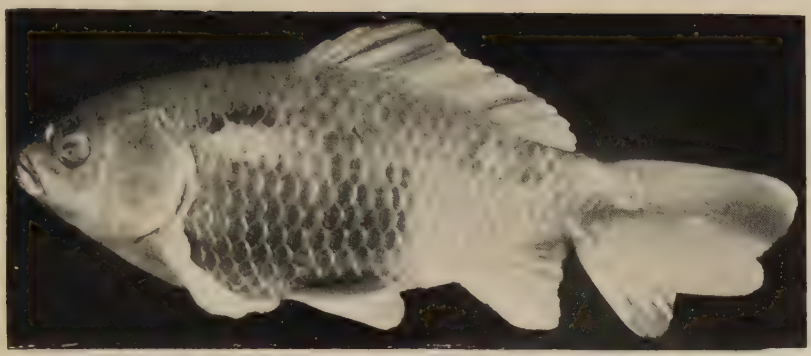
PL. VIII.



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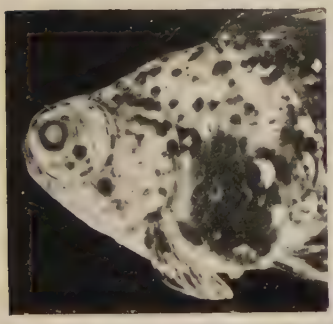

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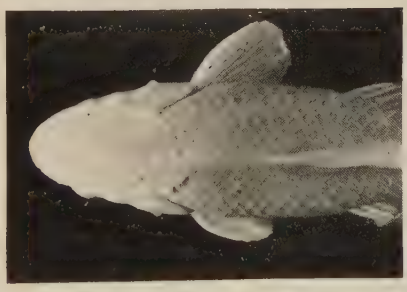

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3. On the Inheritance of the Scale Transparency of Gold-fish.

(Plates IX, X)

Introduction.

The ordinary scale of the gold-fish is lined with an iridocyst layer, consisting of Guanin crystals. It is also found in the corium. The scales appear when the young fish is from 30 to 40 days old, the iridocyst layer in the corium growing on the head and the abdominal region soon after hatching.

The gold-fish however has another kind of scale that is transparent and lacking the iridocyst layer. This was formerly known as a characteristic of the "Sanshoku-demekin" (Calico telescope-eyed gold-fish), but it was found later that some hybrids, such as the "Shubunkin" and the "Calico-ryûkin", or the "Calico-wakin", have also transparent scales. I have already reported the presence of these transparent scales in the wild crusian carp[1] and the-carp[2, 3] also. Although the transparent scales are usually found mingled with the ordinary ones in a mosaic sort of way, I have, in breeding certain gold-fish, come across some fish with only transparent scales. Generally speaking, body de-colouration[4], a very prominent characteristic of some gold-fish, is not found prominently in fishes with transparent scales, but in the spring of 1927, I obtained some mutants with transparent scales and showing ordinary de-colouration, but lacking the iridocyst layers in netlike form.

This paper is a report on the results of researches on the genetics of gold-fish, on which I have been engaged since 1918 under the kind guidance of Professor Kiichi Miyake, at Nakamura Fisheries Institute, in Tokyo, and have been experimenting since 1920 at Toyohashi. I am greatly indebted for invaluable help received to Dr. C. Ishikawa, Messrs. T. Higurashi, S. Hoshino, M. Tokuhisa and the late Mr. K. Akiyama. I am also indebted to Dr. H. Uda for many kind suggestions, and to

Messrs. E. Akiyama, T. Watanuki, T. Takai, I. Andô, Y. Muramatsu, S. Arita, and M. Matsuda, my able assistants, for valuable help rendered in the course of my experiments.

Materials.

A number of Wakin, Aka-demekin, Kuro-demekin, and Funa (crucian carp), whose normal scales had been proved by experiments to be homozygous, were used. A number of Sanshoku-demekin with transparent scales. These scales were proved to be heterozygous, consisting of normal and transparent ones in a mosaic condition. In some of the experiments I used fish with all transparent scales.

Gold-fish with transparent scales may be classified into

1. Gold-fish with transparent scales only.
    a. Those which, lacking the iridocyst layers in the coria, have transparent opercula and irises. (Pl. IX, Figs. 6, 7, 8).
    b. Those which lack in part the iridocyst layers in the coria, i.e., the operculum or the iris on either side is transparent, with opaque parts all over the body. (Pl. IX, Fig. 9).
    c. Those which have iridocyst layers in the coria and opercula, while the irises and other part of the body are opaque (Pl. IX, Fig. 10).
2. Gold-fish with transparent scales in a mosaic condition.
    a. Those which lack iridocyst layers in the scales on all the coria, except in the normal scales, i.e., the opercula, irises, and the abdominal regions are transparent.
    b. Those which lack in part the iridocyst layers in the coria, i.e., the operculum or the iris on either side is transparent (Pl. IX, Fig. 11).
    c. Those which have the iridocyst layers in the coria (Pl. X, Figs. 12, 13).

Of the above mentioned, I have treated 1. as "all-transparent-scaled fish" and 2. as "mosaic transparent-scaled". The mere term "transparent scales" in this paper means that both 1. and 2. are not distinguishable until the fish have reached a certain period of growth.

Mutants with new transparent-scaled were obtained[6] in 1927 from pure Wakin which for several generations had ordinary scales, showing the same de-colouration as that of the normally scaled fish and lacked their iridocyst layers in netlike manner. These I have named[7] "the net-like transparent-scaled fish".

In this paper, the first two numerals in every number of the experiment show the date of same, e.g., Exp. No. 18041 means that the experiment was made in 1918.

Experimental Results.

I. Sanshoku-demekin (Calico telescope-eyed gold-fish).

This race mostly consists of fish with mosaic transparent scales. By in-breeding they segregated into transparent-scaled fish and normal-scaled ones; all transparent-scaled fish being rare as a race.

Table 1. Exp. No. 18043, Sanshoku-demekin self-breeding.

	Transparent scaled	Normal scaled	Total	σ*	p.ε.*	$\frac{\sigma}{\text{p.ε.}}$
Number	658	221	879	—	—	—
Ratio	2.9943	1.0057	4.0000	±0.0057	±0.0394	0.14

* σ = deviation * p.ε. = probable error.

The two scaled characters segregated 3 : 1, but the fish upon being carefully examined when adult gave the ratio 1 : 2 : 1, as shown in Table 2. This shows that the parents were mosaic hybrids with both of the scaled characters, and also that the mosaic transparent-scaled fish are heterozygous.

Table 2.

	All transparent-scaled	Mosaic transparent-scaled	Normal-scaled	Total
Number	186	384	209	779
Ratio	0.9551	1.9717	1.0732	4.0000
σ	−0.0449	−0.0283	0.0732	—
p.ε.	±0.0419	±0.0483	±0.0419	—
$\frac{\sigma}{\text{p.ε.}}$	1.07	0.59	1.75	—

II. Transparent-scaled Fish crossed with Normal-scaled Fish.

Table 3.

Exp. No.	Parents	Transparent scaled		Normal scaled		Total		σ	p.e.	$\frac{\sigma}{\text{p.e.}}$
		Number	Ratio	Number	Ratio	Number	Ratio			
2203	Kuro-demekin × Sanshoku-demekin	97	0.9282	112	1.0718	209	2.0000	±0.0718	±0.0467	1.54
2604	„	90	1.2000	60	0.8000	150	2.0000	±0.2000	±0.0551	3.64
2605	Sanshoku-demekin × Kuro-demekin	42	1.1053	34	0.8947	76	2.0000	±0.1053	±0.0774	1.36
2204	Sanshoku-demekin × Aka-demekin	370	1.1045	300	0.8955	670	2.0000	±0.1045	±0.0824	1.27
18041	Sanshoku-demekin × Wakin	931	1.0053	941	0.9947	1872	2.0000	±0.0053	±0.0156	0.34
2206	„	177	0.9725	187	1.0275	364	2.0000	±0.0275	±0.0355	0.77
18042	Wakin × Sanshoku-demekin	1400	0.9692	1449	1.0308	2889	2.0000	±0.0308	±0.0125	2.46
2301	Sanshoku-demekin × Funa	49	1.0103	48	0.9897	97	2.0000	±0.0103	±0.0685	0.15
2601	„	140	0.8235	200	1.1765	340	2.0000	±0.1765	±0.1157	1.53

All these segregated the two scaled characters above mentioned in a 1 : 1 ratio. The F_1 of the crossings of Sanshoku-demekin with Kuro-demekin, or Aka-demekin, or Wakin etc. show that the colour of the transparent-scaled fish are almostly a piebald of orange and white, while fish with mottled colours like the Sanshoku-demekin are very few in number ; also that those with normal scales, after showing de-colouration, become orange, orange and white piebalds, or white. On the other hand, the F_1 of the Sanshoku-demekin crossed with the Funa shows that the transparent-scaled fish acquire mottled colouring like those of their parent—Sanshoku-demekin—or orange and iron piebalds, but many normal-scaled fish show no de-colouration.

F_2 Generation.

a). Transparent-scaled fish, self-breeding.

Table 4.

Exp. No.	Parents	Transparent-scaled		Normal-scaled		Total		σ	p.ε.	$\frac{\sigma}{\text{p.ε.}}$
		Number	Ratio	Number	Ratio	Number	Ratio			
21401	18041 F_1	109	2.7949	47	1.2051	156	4.0000	±0.2051	±0.0935	2.20
2929	2206 F_1	247	2.9493	88	1.0507	335	4.0000	±0.0507	±0.0638	0.79
2608	2306 F_1	541	2.8738	212	1.1262	753	4.0000	±0.1262	±0.0470	2.69

Table 5.

Exp. No.	Parents		All transp. scaled	Mosaic transp. scaled	Normal-scaled	Total
2929	2206 F_1	Number	11	30	15	56
		Ratio	0.7856	2.1429	1.0714	4.0000
		σ	−0.2143	0.1429	0.0714	—
		p.ε.	±0.1561	±0.1803	±0.1561	—
		$\frac{\sigma}{\text{p.ε.}}$	1.37	0.79	0.46	—
2927	2206 F_1	Number	62	143	84	289
		Ratio	0.8581	1.9792	1.1626	4.0000
		σ	−0.1419	−0.0208	0.1627	—
		p.ε.	±0.0687	±0.0794	±0.0687	—
		$\frac{\sigma}{\text{p.ε.}}$	2.07	0.26	2.37	—
2608	2306 F_1	Number	86	178	104	368
		Ratio	0.9348	1.9348	1.1304	4.0000
		σ	−0.0652	−0.0652	0.1304	—
		p.ε.	±0.0609	±0.0703	±0.0609	—
		$\frac{\sigma}{\text{p.ε.}}$	1.07	0.93	2.14	—

The two scaled characters mentioned segregated 3 : 1, or 1 : 2 : 1, while the transparent-scaled fish of F_1 are heterozygous.

b). Normal-scaled fish, self-breeding.

Table 6.

Exp. No.	Parents	Transparent-scaled	Normal-scaled	Total
21403	18041 F_1	0	82	82
21404	„	0	64	64
2211	„	0	120	120
2719	2206 F_1	0	287	287
2503	2306 F_1	0	1698	1698
2801	2601 F_1	0	222	222

All are normal-scaled fish, the normal-scaled fish of F_1 being homozygous.

Back crossings.

a). F_1 of transparent-scaled fish crossed with Sanshoku-demekin.

Table 7.

Exp. No.	Parents		All transp. scaled	Mosaic transp. scaled	Normal scaled	Total
21413	1804 F_1 × Sanshoku-demekin	Number	340		120	460
		Ratio	2.9565		1.0435	4.0000
		σ	0.0435		−0.0435	—
		p.ε.	±0.1723		±0.1723	—
		$\frac{\sigma}{\text{p.ε.}}$	0.20		0.20	—
21414	All transparent scaled fish × 1804 F_1	Number	170	210	0	380
		Ratio	0.8947	1.1053	—	2.0000
		σ	−0.1053	0.1053	—	—
		p.ε.	±0.0346	±0.0346	—	—
		$\frac{\sigma}{\text{p.ε.}}$	3.04	3.04	—	—
31002	Sanshoku-demekin × 2601 F_1	Number	21	33	16	70
		Ratio	1.2000	1.8857	0.9143	4.0000
		σ	0.2000	−0.1143	−0.0857	—
		p.ε.	±0.1376	±0.1612	±0.1396	—
		$\frac{\sigma}{\text{p.ε.}}$	1.43	0.71	0.61	—

As I had expected, these are transparent-scaled and normal-scaled fish, that is, those with all transparent scales, mosaic transparent scales, and normal scales have segregated in 1 : 1, or 1 : 2 : 1 ratio.

b). F_1 of transparent-scaled fish crossed with normal-scaled one.

Table 8.

Exp. No.	Parents	Mosaic transparent-scaled		Normal-scaled		Total		σ	p.ε.	$\frac{\sigma}{\text{p.ε.}}$
		Number	Ratio	Number	Ratio	Number	Ratio			
22407	1804 F_1 × Wakin	207	1.0753	178	0.9247	385	2.0000	±0.0294	±0.0818	0.36
21405	1804 F_1 × Kuro-demekin	88	1.0057	87	0.9943	175	2.0000	±0.0057	±0.0510	0.11
2706	2306 F_1 × Funa	250	0.8065	370	1.1935	620	2.0000	±0.1935	±0.0857	2.26

Again, as I had expected, the mosaic transparent-scaled and normal-scaled fish segregated in a 1 : 1 ratio.

c). F_1 of normal-scaled fish crossed with Sanshoku-demekin.

Table 9.

Exp. No.	Parents	Mosaic transparent-scaled		Normal-scaled		Total		σ	p.ε.	$\frac{\sigma}{\text{p.ε.}}$
		Number	Ratio	Number	Ratio	Number	Ratio			
2205	1804 F_1 × Sanshoku-demekin	141	1.0181	136	0.9819	277	2.0000	±0.0181	±0.0573	0.32
21409	Sanshoku-demekin × 1804 F_1	72	0.8834	91	1.1166	163	2.0000	±0.1166	±0.0528	2.21
2804	Sanshoku-demekin × 2601 F_1	69	0.8165	100	1.1834	169	2.0000	±0.1834	±0.0519	3.53

As I had expected, the mosaic transparent-scaled and the normal-scaled fish segregated in a 1 : 1 ratio.

d). F_1 of normal-scaled fish crossed with normal-scaled ones.

Table 10.

Exp. No.	Parents	Transparent-scaled	Normal-scaled	Total
21416	Wakin × 1804 F_1	0	155	155
21415	1804 F_1 × Wakin	1	89	90
21411	1804 F_1 × Kuro-demekin	0	513	513
21412	Aka-demekin × 1804 F_1	0	125	125
2209	„	0	185	185
2930	Kuro-demekin × 2601 F_1	0	1395	1395

All the fish, except one with mosaic transparent-scaled, i.e. No. 21415, came out, as I had expected, with normal scales.

Besides the above mentioned, I made experiments with F_3, F_4, and back cross F_2, with segregation results just as I had expected, but I shall omit their description here.

III. On the Net-like Transparent-scaled Fish.

In the spring of 1927, when I was experimenting on the hereditary nature of the caudal fins of the Wakin, I obtained two groups of young fish from those that had distinctly normal scales in the three previous generations, and one of these groups had the same normal scales as those of their parents. From the other I obtained some with transparent scales, as shown in the following Table.

Table 11. Exp. No. 2701, Wakin self-breeding.

	Transparent scaled fish	Normal scaled fish	Total	σ	p.ε.	$\frac{\sigma}{\text{p.ε.}}$
Number	127	360	487	—	—	—
Ratio	1.0431	2.9569	4.0000	±0.0431	±0.0529	0.81

These new transparent scales, quite contrary to the oridinary transparent ones, segregated normal-scaled in the ratio 1 : 3, with distinct decolouration just like fish with normal scales. That is, the scales with iron colour grew black, with sedimentation of melanophore after 30 to 40 days since hatching, the colour later disappearing here and there, producing yellow spots instead, which at last changed into orange (Pl. X, Figs. 15, 16, 17), while some changed to white (Pl. X, Fig. 18). And whereas the ordinary transparent scales lacked iridocyst layer all over the scale, the new transparent scales lacked them in the net-like condition, so that it could very easily be distinguished from the ordinary ones. These new scales, with hereditary character, appeared in recessive mutation, as I shall show in describing my later experiments.

Out of 487 fish I obtained 127 mutants, but owing to unsatifactory environments, most of them died during the rearing, leaving only a few males. I therefore could not propagate them by self-breeding. Further experiments with the same offspring have, however, produced many similar mutants shown in following Tables :

Table 12. Exp. No. 2701, Normal-scaled fish, self-breeding.

Exp. No.	Netlike t. s.		Normal-scaled		Total		σ	p.ε.	$\frac{\sigma}{\text{p.ε.}}$
	Number	Ratio	Number	Ratio	Number	Ratio			
2924	167	1.1041	438	2.8959	605	4.0000	±0.1041	±0.0475	2.19
2925	—	—	290	—	290	—	—	—	—

I then experimented with the next generation of Exp. No. 2925, and obtained 146 normal-scaled fish only. That is, the fish in No. 2924, which were normal-scaled of the phenotype, segregated net-like transparent-scaled and normal-scaled in the ratio 1 : 3, while in Exp. No. 2925 they were all normal-scaled fish of the genotype. In these two cases the normal-scaled fish could not be distinguished by mere external appearances. I tried on these net-like transparent-scaled fish the following experiments:

a. Net-like transparent-scaled fish crossed with normal-scaled ones.

Table 13.

Exp. No.	Parents	Netlike transp. scaled	Normal-scaled	Total
31012	Wakin × 2924	0	286	286
32012	Funa × 2924	0	720	720

The net-like transparent-scaled character showed itself to be recessive against the normal-scaled character.

Table 14. Exp. No. 3016.

Crossing of Exp. No. 2701 normal-scaled fish with net-like transparent-scaled ones of the same Exp. No. 2701.

	Net-like transp. scaled	Normal-scaled	Total	
Number	154	171	325	$\sigma = \pm 0.0523$,
Ratio	0.9477	1.0523	2.0000	p.ε. $= \pm 0.0374$, $\frac{\sigma}{\text{p.ε.}} = 1.40$

The two scaled characters segregated in the ratio 1 : 1, while in the next generation of the fish, I obtained young as shown in the following Table.

Table 15.

Exp. No.	Parents	Net-like t.s.		Normal s.		Total	
		Number	Ratio	Number	Ratio	Number	Ratio
32019	Net-like t.s. fish self-breeding	72	—	0	—	72	—
32020	„	19	—	0	—	19	—
32021	„	136	—	0	—	136	—
32018	Normal-scaled fish self-breeding	0	—	143	—	143	—
32022	Normal s. f. × Net-like t.s.f.	0	—	175	—	175	—
33010	„ „	0	—	856	—	856	—
33025	Net-like t.s.f. × Normal-scaled f.	168	1.0030*	167	0.9970*	355	2.0000

* $\sigma = \pm 0.0030$. p.e. $= \pm 0.0369$. $\frac{\sigma}{\text{p.e.}} = 0.08$.

In Exp. Nos. 32019, 32020, 32021, 33025, I obtained the expected results, while Exp. Nos. 32018, 32022, 33010, are unexpected, since they ought to have segregated the net-like transparent ones. I obtained only fish with normal scales. The result of Exp. No. 33025 is reciprocal crossing of Exp. Nos. 32022 and 33010, but its segregation ratio is quite different. This may show the existence of some sexual relation between them, which will be ascertained by further experiments. The unexpected results were made clear by the following experiments in the next generations.

Table 16.

Exp. No.	Parents	Netlike transp. scaled fish		Normal-scaled fish		Total		σ	p.e.	$\frac{\sigma}{\text{p.e.}}$
		Number	Ratio	Number	Ratio	Number	Ratio			
33013	32018 Norm. s. f. self-breeding	0	—	740	—	740	—	—	—	—
33011	3016 Netlik. t. s. f. × 32018 Nor. s. f.	566	1.0098	555	0.9902	1121	2.0000	±0.0098	±0.0201	0.49
33012	32018 Norm. s. f. × 3016 Netiik. t. s. f.	546	0.9945	552	1.0055	1098	2.0000	±0.0055	±0.0204	0.27
33026	32022 Norm. s. f. self-breeding	165	0.9910	501	3.0090	666	4.0000	±0.0090	±0.0671	0.13
33006	32022 Norm. s f. × 3016 Netlik. t.s.f.	30	1.0909	25	0.9091	55	2.0000	±0.0909	±0.0910	1.00
33007	3016 Netlik. t.s.f. × 32022 Norm. s. f.	186	1.0362	173	0.9638	359	2.0000	±0.0362	±0.0356	1.02
33009	Ditto.	176	0.9288	203	1.0712	379	2.0000	±0.0712	±0.0346	2.06

b. Net-like transparent-scaled fish crossed with mosaic transparent-scaled fish.

Table 17.

Exp. No.	Parents	Normal-scaled-fish		Mosaic transp. scaled fish		Total		σ	p.ε.	$\frac{\sigma}{\text{p.ε.}}$
		Number	Ratio	Number	Ratio	Number	Ratio			
3017	Sanshoku-demekin × 2701 Netlik. t.s.f.	93	0.9588	101	1.0412	194	2.0000	±0.0412	±0.0484	0.85
31010	2709 Mosaic t.s.f. × 2924 Netlik. t.s.f.	354	1.0341	379	0.9659	733	2.0000	±0.0341	±0.0249	1.37
32013	31001 Mosaic t.s.f. × 2924 Netlik. t.s.f.	189	0.9793	197	1.0207	386	2.0000	±0.0207	±0.0343	0.60

Instead of getting net-like transparent-scaled fish, I obtained mosaic transparent-scaled and normal-scaled fish, which segregated themselves in the ratio 1 : 1. The F_2 segregated as in the following Table:

Table 18.

Exp. No.	Parents		Netlike t. scaled	Normal-scaled	Transparent scaled	Total
32024	3017 mosaic transp. scaled-fish	Number	7	20	117	144
		Ratio	0.7778	2.2222	13.0000	16.0000
		σ	−0.2222	−0.7778	1.0000	—
		p.ε.	±0.2177	±0.3510	±0.3894	—
		$\frac{\sigma}{\text{p.ε.}}$	1.02	2.22	2.60	—
33017	„	Number	96	296	1257	1649
		Ratio	0.9315	2.8720	12.1965	16.0000
		σ	−0.0685	−0.1280	0.1965	—
		p.ε.	±0.0643	±0.1037	±0.1151	—
		$\frac{\sigma}{\text{p.ε.}}$	1.07	1.23	1.71	—
32025	3017 normal-scaled fish	Number	49	127	0	176
		Ratio	1.1136	2.8864	—	4.0000
		σ	0.1136	−0.1136	—	—
		p.ε.	±0.0881	±0.0881	—	—
		$\frac{\sigma}{\text{p.ε.}}$	1.29	1.29	—	—
33018	31010 mosaic transparent-scaled fish	Number	51	164	598	813
		Ratio	1.0037	3.2275	11.7688	16.0000
		σ	0.0037	0.2275	−0.2312	—
		p.ε.	±0.0916	±0.1477	±0.1639	—
		$\frac{\sigma}{\text{p.ε.}}$	0.04	1.54	1.41	—

The results of self-breeding of mosaic transparent-scaled fish are the segregation ratio of 1 : 3 : 12, and that of normal ones of 3 : 1, but the careful examination of the transparent scale of the adult fish gave the results shown in Table 19.

Table 19.

Exp. No.	Parents		Netlike t.s.	Normal-scaled	Mosaic t.s.	All transp. scaled	Total
32024	3017 mosaic transparent-scaled fish	Number	7	20	64	53	144
		Ratio	0.7778	2.2222	7.1111	5.8889	16.0000
		σ	−0.2222	−0.7778	1.1111	−0.1111	—
		p.ε.	±0.2177	±0.3510	±0.4354	±0.4354	—
		$\frac{\sigma}{\text{p.ε.}}$	1.02	2.22	2.55	0.26	—
33017	Ditto	Number	96	296	656	601	1649
		Ratio	0.9315	2.8720	6.3651	5.8314	16.0000
		σ	−0.0685	−0.1280	0.3651	−0.1686	—
		p.ε.	±0.0643	±0.1037	±0.1287	±0.1287	—
		$\frac{\sigma}{\text{p.ε.}}$	1.07	1.23	2.84	1.31	—
33018	31010 mosaic transparent-scaled-fish	Number	47	125	257	189	618
		Ratio	1.2168	3.2363	6.6537	4.8932	16.0000
		σ	0.2168	0.2363	0.6537	−1.1068	—
		p.ε.	±0.1051	±0.1694	±0.2102	±0.2102	—
		$\frac{\sigma}{\text{p.ε.}}$	2.06	1.39	3.11	5.27	—

It segregated in the ratio 1 : 3 : 6 : 6, but the numbers of all-transparent-scaled fish in Exp. No. 33018 is small, while its deviation is larger than five times the probable error, which may be due to weakness of the all-transparent-scaled fish.

The results of the back cross experiments are as in Table 20.

The four scaled characters segregated in the ratio 1 : 1 : 1 : 1, but in the result of Exp. No. 33016, the deviations are larger than its reciprocal crossing. This difference of segregation ratio in the reciprocal crossing occured also in the Exp. No. 33025 (Table 15), and it is remarkable to

note that in both cases the net-like transparent-scaled fish were usually females. They may show the existence of some sexual relations in crossing.

Table 20. Back crossings.

Exp. No.	Parents		Netlike t.s.	Normal-scaled	Mosaic t.s.	All transp. scaled	Total
33015	3017 mosaic transp. scaled-fish × 3016 netlike transp. scaled-fish	Number	130	152	152	161	595
		Ratio	0.8740	1.0218	1.0218	1.0824	4.0000
		σ	−0.1260	0.0218	0.0218	0.0824	—
		p.ε.	0.0479	0.0479	0.0479	0.0479	—
		$\frac{\sigma}{\text{p.ε.}}$	2.63	0.46	0.46	1.72	—
33016	Reciprocal cross	Number	90	69	110	71	340
		Ratio	1.0588	0.8118	1.2941	0.8353	4.0000
		σ	0.0588	−0.1882	0.2941	−0.1647	--
		p.ε.	±0.0636	±0.0636	±0.0636	±0.0636	—
		$\frac{\sigma}{\text{p.ε.}}$	0.92	4.53	4.62	2.59	—

General Discussion.

It appears, according to the experiments, that although the transparent scaled character is dominant over the normal-scaled, upon the transparent scales being further classified, they seem to be mosaic hybrid, so that the question as to whether it is dominant or recessive remains obscure, but there is no question that the normal-scaled character is dominant over the net-like transparent-scaled character, which is recessive against the ordinary transparency.

By denominating the gene symbol T for the transparency, t for the normal, and n for the net-like transparency, and N for the allelomorphic gene of it, and with n and N hypostatic against T, then in the mosaic transparency of the scales, the normal scales found among the transparent ones is mosaic, so that the N gene is necessary to appear the normal scales in them, and since according to experiments, the mosaic transparency of scales is a heterozygote. The constitution of each of the

scale characters will be as follows :—

1. All transparent-scaled character — *TTNN, TTNn, TTnn, Ttnn.*
2. Mosaic transparency of scales — *TtNN, TtNn.*
3. Normal-scaled character — *ttNN, ttNn.*
4. Net-like transparency of scales — *ttnn.*

It is remarkable that there are two kinds of transparency in all scales, viz. homozygous and heterozygous in *T* gene.

If we express the foregoing results with these notations, Exp. Nos. 18043, 21401, 2929, 2927, 21413, 31002, 2608 (Tables 1, 4, 5, 7) are *TtNN*× *TtNN* and, as the gametic combination is $(TN+tN)^2=1$ *TTNN*+2*TtNN*+ 1 *ttNN*, the all transparent-scaled fish, the mosaic transparent-scaled, and the normal-scaled are segregated in the ratio 1 : 2 : 1, or the transparent-scaled fish and the normal-scaled ones in the ratio 3 : 1, all of which agree with the results of the experiments.

Likewise, Exp. Nos. 2203, 2604, 2605, 2204, 18041, 18042, 2206, 2306, 2601, 22407, 21405, 2706, 2205, 21409, 2804 (Tables 3, 8, 9) are *TtNN*×*ttNN*, or *ttNN*× *TtNN* (reciprocal cross), the gametic combination being (*TN*+*tN*) ×*tN*= *TtNN*+*ttNN*, which agrees with the fact that the mosaic transparent-scaled fish and the normal-scaled ones are segregated in the ratio 1 : 1. As Exp. No. 21414 (Table 7) is *TTNN*× *TtNN*, we have *TN*×(*TN*+*tN*)= *TTNN*+ *TtNN*, the all transparent-scaled fish and the mosaic transparent-scaled ones having segregated in the ratio 1 : 1. Exp. Nos. 21403, 21404, 2211, 2719, 2503, 2801, 21416, 21415, 21411, 21412, 2209, 2930 (Tables 6, 10) are *ttNN*×*ttNN*, that is to say, *tN*×*tN*=*ttNN*, which is the homozygote of the normal-scaled character.

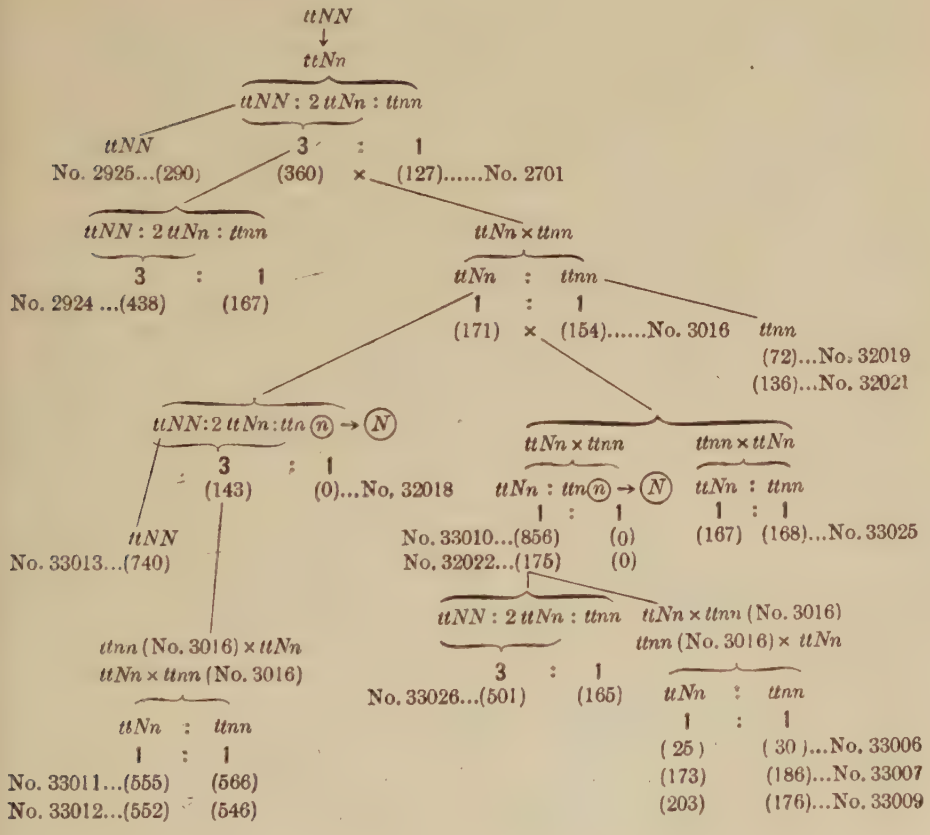
Now it is quite clear from the foregoing that the transparent-scaled and the normal-scaled characters are inherited as a Mendelian monohybrid and the mosaic transparent-scaled character as a mosaic hybrid of the two.

Supposing again that the net-like transparent-scaled character is the result of one of the *N* gene of the normal scale gene *ttNN* having become a *n* by recessive mutation, then Exp. 2701 may be the crossing of *ttNn* with *ttNn*, in which case the gametic conbination will be $(tN+tn)^2=ttNN+2ttNn$ +*ttnn*, and since *ttNn* is a phenotype of the normal-scaled, this segregation brings the normal-scaled fish and the net-like transparent-scaled ones in a 3 : 1 ratio, which quite agrees with the results of the experiments. The same may also be proved by Exp. Nos. 31012, 32012 (Table 13), which is *ttNN*× *ttnn*, the gametic combination being *tN*× *tn*=*ttNn*, and normal-

scaled fish alone are produced.

The fact that the two scaled characters showed a ratio of 1 : 1 when the net-like transparent-scaled fish (result of Exp. No. 2701) was crossed with the normal-scaled ones (Exp. No. 3016, Table 14) is also confirmed by the above mentioned genic constitution. Exp. Nos. 32019, 32020, 32021, 33025 of F_3 (Table 15) are also the natural results of factor constitution. Although Exp. Nos. 32018, 32022, 33010 (Table 15), which by factor constitution are $ttNn \times ttNn$ and $ttNn \times ttnn$, and ought to produce normal-scaled and net-like transparent-scaled fish in the ratio of 1 : 1, they actually produced only normal-scaled fish. This contradicts our expectation, but it is possible that the n of the $ttNn$ became N again by reverse mutation. These relations are made clear by Table 16, 21.

Table 21.



Exp. Nos. 3017, 31010, 32013 (Table 17) are $TtNN \times ttnn$, the gametic combination being $(TN+tN) \times tn = TtNn + ttNn$. The mosaic transparent scaled and the normal-scaled fish appeared in the ratio of 1 : 1.

Exp. Nos. 32024, 33017, 33018 (Table 19) are F_2, and a crossing of $TtNn$ with $TtNn$, making the gametic combination $(TN+Tn+tN+tn)^2 = TTNN+2\ TTNn+4\ TtNn+TTnn+2\ Ttnn+ttNN+2\ ttNn+ttnn$, which may divided, according to the phenotypes, into net-like transparent-scaled fish 1 : normal-scaled 3 : mosaic transparent-scaled 6 : all-transpent-scaled 6. This is a special segregation of dihybrid, and agrees with the results of the experiments, and proved this by the results of back crossing experiments as shown in the Table 20.

Exp. Nos. 32025 (Table 18), 2924 (Table 12), which are crossings of $ttNn$ with $ttNn$, may be expressed as $(tN+tn)^2 = ttNN+2\ ttNn+ttnn$, while Exp. No. 2925 (Table 12), which is a case of $ttNN$, and can be proved by Exp. No. 32011 (Table 21).

We see from the foregoing that the net-like transparent-scaled character is hereditarily related to the normal-scaled character as a monohybrid and to the transparent-scaled character as a dihybrid.

On looking back now at studies made in the past on the inheritance of the gold-fish, I find that in the late Professor K. Toyama's work in 1908—1917, although a few observations on the scale characters have been attempted, most of them concerned the character of the eyes and fins of gold-fish, and it is a matter for regret that no definite conclusions are possible from their records. Mr. Higurashi (1914)[8], preliminarily pointed out that the transparent-scaled character is dominant over the normal-scaled character. Dr. Berndt (1925)[9] tried to show that the transparent-scaled character (HyHy) is dominant over the normal-scaled character (hyhy). Dr. Chen (1928)[10], in classifying the transparent-scaled character into the homozygous and the heterozygous, wherein he gave the symbol T' to transparent scales and T to normal scales, showed that fish with T' and T heterozygous have mosaic scales, and that the bodies of these gold-fish have mottled colours, calling these fish "mottled fish". He added the remark that fish with homozygeus T' have their all-transparent bodies without pigments, and that in the normal-scaled character, T is homozygous, T' being dominant over T.

My experiments furnished some points of agreement with these opinions, but whereas the scale character is generally supposed to be monohybrid, my opinion is that the constitution of the gene is dihybrid,

inherited partly as monohybrid and partly as dihybrid — an opinion based on the results of my studies on the new mutant — the net-like transparent-scaled character.

Dr. Chen (1928)[10] believes that the scale character and the body colour character are governed by the same gene, but my studies lead me to conclude that they are governed by different genes; for despite Dr. Chen's statement that the homozygous transparent scales lack pigments, my experiments have shown that these scales have sometimes mottled colours (Pl. IX, Fig. 8). Moreover some heterozygous mosaic transparent-scaled fish have no mottled colours, and in the hybrids of the Sanshoku-demekin and the Wakin especially, it is common for them to have no mottled colours notwithstanding that they have mosaic transparent scales, while in the F_1 of the Sanshoku-demekin and the Funa, the transparent-scaled fish have mottled (Pl. IX, Fig. 5) or varied colours (Pl. X, Figs. 12, 13). In the latter case, particularly, the black spots gradually disappear. In such hybrids, it is very common for the normal-scaled fish to show no de-colouration.

Therefore, in so far as the inheritance of the body colouration of the gold-fish is concerned there still remain unanswered many questions concerning the specially interesting phenomenon of de-colouration, which I shall treat in another place.

Dr. Chen next called attention to his "exceptional transparent scaled fish". From his description it seems very probable that his fish is nothing more than my mutants with the scales of net-like transparency. The difference at all events, is that, whereas his experiments showed that the F_1, i.e., the crossings of the exceptional transparent-scaled fish with the normal-scaled ones, were all normal-scaled fish, and that all the offspring from mating the exceptional-scaled females with the exceptional males were normal-scaled fish, the exceptional transparent-scaled fish is a somatic mutation, while those which had *TT* genetically have revealed transparenty phenotypically. In my experiments, however, the net-like transparent-scaled character is no doubt hereditary, being recessive against the normal-scaled character.

As to Dr. Chen's opinion, I must say that it is quite natural that the F_1 produced by crossing the exceptional transparent-scaled fish with the normal-scaled ones, should turn out to be normal-scaled fish, for the former are recessive against the latter. And if, as shown by my experiments, the case in which the normal-scaled were heterozygous could be explained as a result of the *n* gene having become a *N* gene through

reverse mutation, the results of his latter experiments then — though in my own experiments I obtained net-like transparent-scaled fish only — can be explained in like manner.

Summary.

1. In the gold-fish we have the normal-scaled, the transparent-scaled, and the net-like transparent-scaled characters, the transparent ones consisting of the all-transparent-scaled character and the mosaic transparent scaled. The mosaic transparent-scaled character, which is heterozygous, is a mosaic hybrid between the normal-scaled character and the transparent-scaled one. The net-like transparent-scaled character is a recessive mutant from the normal-scaled character, and is inherited also recessively against the transparent-scaled one.

2. As the Sanshoku-demekin have a mosaic transparent-scaled character, they segregate all-transparent-scaled fish and the mosaic transparent-scaled ones and the normal-scaled in the ratio of 1 : 2 : 1, in self-breeding, while in the crossing with the normal-scaled Wakin, Funa, etc., they segregate the mosaic transparent-scaled and normal-scaled fish in a 1 : 1 ratio.

In the crossing of the net-like transparent-scaled character with the normal-scaled character, the F_1 is a normal-scaled fish, while in the F_2 it segregates the normal-scaled and the net-like transparent-scaled characters in a 3 : 1 ratio.

In mating the net-like transparent-scaled with the mosaic transparent-scaled characters, the mosaic transparent-scaled and the normal-scaled characters are segregated in the ratio of 1 : 1, without any net-like transparent-scaled fish. In F_2, the net-like transparent-scaled, the normal-scaled, the mosaic transparent-scaled, and the all-transparent-scaled are produced in a special segregation of the dihybrid in the ratio of 1 : 3 : 6 : 6.

3. The transparent-scaled character and the normal-scaled character are inherited as monohybrid, and the net-like transparent-scaled character and the normal-scaled as monohybrid, while the net-like transparent-scaled and the mosaic transparent-scaled character are inherited as dihybrid. Then adopting T as the gene symbol for scale transparency, t for normal, n for the net-like transparency, and N for the allelomorph of it, and N and n hypostatic against T, and also from the results of experiments, the

mosaic transparent-scaled is heterozygote of transparency and normal-scaled. The genic constitution of each scaled character is then as follows :—

All transparent-scaled character	*TN, Tn*
Mosaic transparent-scaled character	*TtN*
Net-like transparent-scaled character	*tn*
Normal-scaled character	*tN*

4. It seems that the body colouration of the gold-fish is governed by a gene that differs from the scaled character.

5. The net-like transparent-scaled character is what is produced from one of the *N*'s in the *ttNN* of the normal-scaled character, which changes into *n* by recessive mutation, but which sometimes changes back again to *N* by reverse mutation in the crossing with the normal scaled character.

November, 1933.

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Explanation of Figures. (Plates IX, X).

Fig. 1. Sanshoku-demekin (mosaic transparent-scaled).
Fig. 2. Wakin (normal-scaled).
Fig. 3. Funa (normal-scaled).
Fig. 4. Hybrid of Sanshoku-demekin and Wakin (mosaic transparent-scaled).
Fig. 5. Hybrid of Sanshoku-demekin and Funa (mosaic transparent-scaled).
Fig. 6. Colourless all-transparent-scaled fish.
Fig. 7. Orange and white piebald form of all-transparent-scaled fish.
Fig. 8. Mottled all-transparent scaled fish.
Fig. 9. All transparent-scaled fish which lack in part the iridocyst layers in coria.
Fig. 10. All-transparent-scaled fish which have iridocyst layers in the body.
Fig. 11. Mosaic transparent-scaled fish which lack in part the iridocyst layers in the coria.
Fig. 12. Mosaic transparent-scaled fish.
Fig. 13. Ibid.
Fig. 14. First mutant of netlike transparent-scaled fish. (3rd year).
Fig. 15. Netlike transparent-scaled fish (iron coloured).
Fig. 16. Ibid (de-colouring).
Fig. 17. Ibid (de-coloured).
Fig. 18. Ibid (white).
Fig. 19. Normal-scaled fish (iron coloured).
Fig. 20. Ibid (de-colouring).
Fig. 21. Ibid (de-coloured).
Fig. 22. Hybrid of net-like transparent-scaled fish and mosaic transparent-scaled one.

PL. IX.

PL. X.

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4. On the Inheritance of the Caudal and Anal Fins of the Gold-fish.

(Plates XI, XII)

Introduction

One of the characteristic bodily forms of the gold-fish are their anal and caudal fins. Whereas in ordinary fish the anal and caudal fins are, like the dorsal fins, simple and vertical, some gold-fish have also horizontally paired fins besides the vertical ones. The caudal fins are divided into several classes—the Funa-wo (simple tail), the Tsumami-wo (imperfectly shaped tail of the Mitsu-wo), the Mitsu-wo (tri-lobed tail), the Sakura-wo (shape of tail intermediate between Mitsu-wo and Yotsu-wo), the Yotsu-wo (tetra-lobed tail), the Kujaku-wo (X-shaped tail), etc.

Although the Funa-wo is a vertical fin, the caudal fin of all other gold-fish are horizontally paired. Besides the two kinds of anal fins, single and double, we sometimes meet with Y-shaped and V-shaped intermediate forms, and rarely a gold-fish with either no anal fin or with fins greatly degenerated.

As to the inheritance of the fins of the gold-fish, Dr. C. Ishikawa and the late Dr. K. Toyama, who, since 1900, and with my assistance since 1914, had been conducting a number of experiments, lost all his materials at the time of the great flood in Tokyo and neighbourhood, and consequently had to abandon their studies. Dr. Toyama unfortunatly died in 1918. The same year I resumed experiments with new materials under the kind guidance of Professor K. Miyake, and am still engaged in this study. I shall attempt in this paper to describe some of the results of my experiments during these years, and in doing so, shall refer to some of the experiments (1908—1917) that were made by the late Dr. Toyama.

I take this opportunity of gratefully acknowledging the kindness of the late Dr. Toyama, and of thanking Professor Miyake, Mr. T. Higurashi, Mr. S. Hoshino, and Mr. M. Tokuhisa for help and encouragement given me in various ways in the course of my studies. My acknowledgements in these respects are also due to the late Mr. K. Akiyama. In my breeding experiments, I am greatly indebted, for invaluable help rendered by my able assistants, Messrs. T. Watanuki, T. Takai, Y. Muramatsu, I. Ando, M. Matsuda, and in photographing to Mr. A. Kumada. Thanks are also due to Mr. Kaneyasu Toyama, son of the late Doctor, who so kindly allowed me the use of his father's experiment notes, which were the source of many valuable suggestions.

Materials.

The materials for my experiments were a number of Wakin, Ryûkin, Ranchû, Oranda-shishi-gashira, Sanshoku-demekin, Kuro-demekin, Aka-demekin, Chôtengan, Jikin, Shûkin, Hibuna, and Funa; while for crossing purposes I made use of a number of male and female that had been brought up in separate ponds.

In the present paper I shall call the vertical fins, Funa-wo, and refer to the so-called Tsumami-wo, Mitsu-wo, Sakura-wo, Yotsu-wo, and Kujaku-wo by the name, Hiraki-wo or paired tail. Although the fins with their lower lobes grooved or with irregular shapes, I have classed as imperfectly paired tail, it is very difficult to distinguish the former when young from the Funa-wo. I have also used the word 'mono' for the single anal fin and 'di' for the double anal ones.

The first two numerals in the experiment number stand for the date of the experiment; for example, 1804 means an experiment made in 1918, while all experiments dating after 1918, and with no experimenter's name attached, are mine.

Experimental Results.

I. Experiments on the Caudal Fins.

A. On the gold-fish alone.

Table 1. Mitsu-wo, self-breeding.

Exp. No.	Parents	Tetra-lobe	%	Tri-lobe	%	Imper-fectly paired	%	Paired tail total	Simple	%	Total	Investi-gator
0906	Ryûkin × Ranchû	0	—	869	85.20	83	8.14	952	68	6.66	1020	Toyama
0907	Demekin × Ranchû	0	—	497	95.95	13	2.51	510	8	1.54	518	〃
0912	Demekin × Oranda	0	—	286	75.07	80	21.00	366	15	3.93	381	〃
1401	Ranchû × Ranchû	0	—	43	57.33	16	21.33	59	16	21.33	75	〃
1402	〃	0	—	161	82.99	33	17.01	194	0	—	194	〃
1421	Demekin × Demekin	1206	80.35	173	11.53	109	7.26	1488	13	0.86	1501	〃
1423	Demekin × Ranchû	207	49.29	152	36.19	51	12.14	410	10	2.38	420	〃
1601	Ranchû × Ranchû	46	26.28	119	68.00	5	2.86	124	5	2.86	175	〃
18034	Ryûkin × Ryûkin	381	57.29	273	41.05	10	1.50	654	1	0.15	665	Matsui

Table 2. Yotsu-wo, self-breeding.

Exp. No.	Parents	Tetra-lobe	%	Tri-lobe	%	Imper-fectly paired	%	Paired tail total	Simple	%	Total	Investi-gator
0815	Ryûkin × Demekin	28	50.00	11	19.64	17	30.36	55	0	—	56	Toyama
0820	Ranchû × Chôtengan	0	—	19	55.88	14	41.18	33	1	2.94	34	〃
1425	Kuro-demekin × Kuro-demekin	460	51.45	106	11.86	328	36.69	894	0	—	894	〃
1805	〃	227	55.77	114	28.01	66	16.22	407	0	—	407	Matsui
18043	Sanshoku-demekin × Sanshoku-demekin	763	86.80	99	11.26	17	1.94	879	0	—	879	〃
18042	Wakin × Sanshoku-demekin	2337	80.89	415	14.37	137	4.74	2889	0	—	2889	〃
2605	Sanshoku-demekin × Kuro-demekin	21	27.63	45	59.21	0	—	66	10	13.16	76	〃
2713	Ranchû × Ryûkin	209	84.28	28	11.29	7	2.82	244	4	1.61	248	〃
2718	〃	252	64.95	119	30.67	11	2.83	382	6	1.55	388	〃
2716	Ryûkin × Wakin	235	42.73	313	56.91	0	—	548	2	0.36	550	〃
2714	Ryûkin × Ranchû	30	17.86	85	50.60	39	23.21	154	14	8.33	168	〃
2713	〃	209	84.28	28	11.29	7	2.82	244	4	1.61	248	〃
2712	〃	303	68.86	90	20.46	43	9.77	436	4	0.91	440	〃

Table 3. Kujaku-wo, self-breeding.

Exp. No.	Parents	Kujyaku-wo		Tetra-lobe		Tri-lobe		Imper-fectly paired		Paired-tail total	Simple		Total	Investi-gator
			%		%		%		%			%		
1602	Jikin × Jikin	165	66.53	76	30.65	4	1.61	0	—	245	3	1.21	248	Toyama
18024	〃	274	36.49	331	44.08	4	0.53	125	16.64	734	17	2.26	751	Matsui

Table 4. Mitsu-wo × Yotsu-wo.

Exp. No.	Parents	Tetra-lobe		Tri-lobe		Imper-fectly paired		Paired tail total	Simple		Total	Investi-gator
			%		%		%			%		
18044	Wakin × Wakin	646	26.64	1685	69.49	82	3.38	2414	12	0.49	2425	Matsui
2715	Ryûkin × Ranchû	238	53.97	124	28.12	69	15.64	431	10	2.27	441	〃
2922	Wakin × Wakin	10	2.88	297	85.59	16	4.61	323	24	6.92	347	〃

Table 5. Yotsu-wo × Mitsu-wo.

Exp. No.	Parents	Tetra-lobe		Tri-lobe		Imper-fectly paired		Paired tail total	Simple		Total	Iuvesti-gator
			%		%		%			%		
0801	Wakin × Wakin	14	18.42	59	77.63	2	2.63	75	1	1.32	76	Toyama
18014	〃	429	35.16	754	61.80	37	3.04	1220	0	—	1220	Matsui
18041	Sanshoku-demekin × Wakin	1270	67.84	289	15.44	313	16.72	1872	0	—	1872	〃
18044	Wakin × Wakin	646	26.63	1686	69.50	82	3.38	2414	12	0.49	2426	〃
2206	Sanshoku-demekin × Wakin	27	7.42	267	73.35	70	19.23	364	0	—	364	〃
2604	Kuro-demekin × Sanshoku-demekin	32	21.33	93	62.00	12	8.00	137	13	8.67	150	〃

Table 6. Kujaku-wo × Yotsu-wo.

Exp. No.	Parents	Kujyaku-wo		Tetra-lobe		Tri-lobe		Imper-fectly paired		Paired tail total	Simple		Total	Investi-gator
			%		%		%		%			%		
1638	Jikin × Ryûkin	217	31.96	186	27.39	3	0.44	258	38.00	664	15	2.21	679	Toyama

Table 7. Funa-wo, self-breeding.

Exp. No.	Parents	Tetra-lobe		Tri-lobe		Imper-fectly paired		Paired tail total	Simple		Total	Investi-gator
			%		%		%			%		
0903	Wakin × Wakin	2	1.74	92	80.00	8	6.96	102	13	11.30	115	Toyama
0905	〃	0	—	97	53.30	9	4.95	106	76	41.73	182	〃
1424	〃	95	5.26	287	15.87	351	19.41	733	1075	59.46	1808	〃
1810	Hibuna × Hibuna	0	—	2	0.30	28	4.18	30	640	95.52	670	Matsui
2701	Wakin × Wakin	8	1.69	202	42.80	148	31.36	358	114	24.15	472	〃

Table 8. Tsumami-wo × Imperfectly paired tail.

Exp. No.	Parents	Tetra-lobe		Tri-lobe		Imper-fectly paired		Paired tail total	Simple		Total	Investi-gator
										%		
3017	Tsumami-wo (2711) × Wakin (2701)	—	—	—	—	—	—	166	30	15.31	196	Matsui

With respect to the next generation of the above-mentioned, I made the following experiments:

a) Experiments on Exp. No. 1423 (Mitsu-wo, self-breeding).

Table 9. F_2

Exp. No.	Parents	Tetra-lobe		Tri-lobe		Imper-fectly paired		Paired tail total	Simple		Total	Investi-gator
			%		%		%			%		
1641	Tetra-lobe × Tetra-lobe	44	26.35	3	1.80	120	71.85	167	0	—	167	Toyama Matsui
1642	Tetra-lobe × Funa-wo	34	28.33	7	5.83	75	62.50	116	4	3.34	120	〃
1643	Funa-wo × Funa-wo	18	13.84	67	51.54	42	32.31	127	3	2.31	130	〃

b) Experiments on Exp. No. 18042.

Table 10. F_2.

Exp. No.	Parents	Tetra-lobe	%	Tri-lobe	%	Imper-fectly paired	%	Paired tail total	Simple	%	Total	Investi-gator
21402	Tetra-lobe × Tetra-lobe	15	48.39	15	48.39	1	3.22	31	0	—	31	Matsui
21404	〃	27	42.19	25	39.06	12	18.75	64	0	—	64	〃
22402	〃	72	53.39	47	36.15	9	6.92	128	2	1.54	130	〃
2211	〃	67	55.83	50	41.67	2	1.67	119	1	0.83	120	〃

Table 11. F_3.

Exp. No.	Parents	Tetra-lobe	%	Tri-lobe		Imper-fectly paired	%	Paired tail total	Simple	%	Total
2320	21402 (Imperfectly paired self)	10	31.25	15	46.88	6	18.76	31	1	3.12	32

Table 12. Back cross.

Exp. No.	Parents	Tetra-lobe	%	Tri-lobe	%	Imper-fectly paired	%	Paired tail total	Simple	%	Total
21410	18042 (tetra) × Demekin (tetra)	15	32.61	27	58.70	4	8.69	46	0	—	46
21413	18042 (tetra) × Demekin (tetra)	31	67.39	7	15.22	8	17.39	46	0	—	46
21414	Demekin (tetra) × 18042 (tetra)	4	10.53	21	55.26	9	23.68	34	4	10.53	38
21409	〃	147	90.19	11	6.75	4	2.45	162	1	0.61	163
21407	18042 (tetra) × Wakin (tetra)	25	36.77	41	60.29	1	1.47	67	1	1.47	68
22407	〃	78	20.26	270	70.13	16	4.16	364	21	5.45	385
21411	18042 (tri) × Demekin (tri)	57	25.11	164	72.25	6	2.64	227	0	—	227
21412	Demekin (tri) × 18042 (tri)	2	1.60	103	28.40	13	10.40	118	7	5.60	125
21406	Aka-demekin (tri) × 18042 (tetra)	2	4.55	23	52.27	9	20.45	34	10	22.73	44
21405	18042 (tetra) × Kuro-demekin (tri)	16	9.20	150	86.21	5	2.87	171	3	1.72	174
21416	Wakin (tri) × 18042 (tetra)	11	7.10	136	87.74	7	4.52	154	1	0.64	155

c) Experiments on Exp. No. 2716.

Table 13. F_2.

Exp. No.	Parents	Tetra-lobe	%	Tri-lobe	%	Imper-fectly paired	%	Paired tail total	Simple	%	Total
2912	Tri-lobe × Tetra-lobe	17	12.14	84	60.00	28	20.00	129	11	7.86	140
3011	〃	116	18.59	464	74.36	0	—	580	44	7.05	624

Table 14. Mitsu-wo (Exp. No. 2716) × Funa-wo (Wakin).

Experiment No.	Paired tailed		Simple tailed		Total
2923	1349	99.63%	5	0.37%	1354

d) Experiments on Exp. No. 18041.

Table 15. F_2.

Exp. No.	Parents	Tetra-lobe	%	Tri-lobe	%	Imper-fectly paired	%	Paired tail total	Simple		Total
21401	Tetra-lobe × Tetra-lobe	18	19.56	63	68.48	11	11.96	92	0	—	92
21403	Tetra-lobe × Tri-lobe	16	19.51	65	79.27	1	1.22	82	0	—	82

Table 16. Back cross.

Exp. No.	Parents	Tetra-lobe	%	Tri-lobe	%	Imper-fectly paired	%	Paired tail total	Simple		Total
21415 (2210)	18041 (tetra) × Wakin (tetra)	29	32.22	56	62.22	5	5.56	90	0	—	90

Table 17. Back cross F_2.

Exp. No.	Parents	Tetra-lobe	%	Tri-lobe	%	Imper-fectly paired		Paired tail total	Simple	%	Total
2711	21415 (tri × tri)	14	12.96	91	84.26	0	—	105	3	2.78	108

Table 18. Back cross F_3.

Exp. No.	Parents	Tetra-lobe		Tri-lobe		Imper-fectly paired		Paired tail total	Simple		Total
			%		%					%	
2917	2711 (tri × tri)	0	—	151	75.88	0	—	151	48	24.12	199
31013	2711 (tetra × tri)	12	2.26	516	96.99	0	—	528	4	0.75	532

e) Experiments on Exp. No. 2206.

Table 19. F_2.

Exp. No.	Parents	Tetra-lobe		Tri-lobe		Imper-fectly paired		Paired tail total	Simple		Total
			%		%		%				
2719	Tri-lobe × Tetra-lobe	29	9.86	217	73.81	48	16.33	294	0	—	294

Table 20. F_3.

Exp. No.	Parents	Tetra-lobe		Tri-lobe		Imper-fectly paired		Paired tail total	Simple		Total
					%		%			%	
2927	2719 (tri × Imperfectly paired)	0	—	28	63.64	8	18.18	36	8	18.18	44

Table 21. F_4.

Exp. No.	Parents	Tetra-lobe		Tri-lobe		Imper-fectly paired		Paired tail total	Simple		Total
					%		%				
31004	2927 (tri × tri)	0	—	160	98.77	2	1.23	162	0	—	162

f) Experiments on Exp. No. 2701.

Table 22. F_2.

Exp. No.	Parents	Tetra-lobe		Tri-lobe		Imper-fectly paired		Paired tail total	Simple		Total
			%		%		%			%	
2924	Simple × Simple	19	3.84	156	31.52	15	3.03	190	305	61.61	495
3016	〃	—		—		—		132	193	59.38	325
2925	Tetra-lobe × Tri-lobe	8	3.48	90	39.13	59	25.65	157	73	31.74	230

Table 23. F_3.

Exp. No.	Parents	Tetra-lobe		Tri-lobe		Imper-fectly paired		Paired tail total	Simple		Total
			%		%		%			%	
32011	2925 (Simple tail self)	39	26.71	46	31.51	38	26.03	123	23	15.75	146

g) Experiments on Exp. No. 3017.

Table 24. F_2.

Exp. No.	Parents	Tetra-lobe		Tri-lobe		Imper-fectly paired		Paired tail total	Simple		Total	Investi-gator
			%		%		%			%		
32024	3017 (tri-lobe self)	0	0.69	67	46.53	11	7.64	79	65	45.14	144	Matsui
32025	〃	1	—	33	18.75	17	9.66	50	126	71.59	176	〃

In the foregoing experiments I could not perceive any fixity of character in the Mitsu-wo, the Yotsu-wo, etc., but as paired tails they mostly appear to be homozygous, though there were some exceptions. It is worth noting that they sometimes beget Funa-wo, especially the Jikin, which, notwithstanding that it has been selected from the Kujaku-wo through several tens of generations, segregate Funa-wo. It seems to me therefore, that the Funa-wo is either heterozygous, and consisting of two or more genes, or a case of Non-Mendelian inheritance.

The above-mentioned experiments are chiefly in pure line breeding of the paired tail and the simple tail. In crossings of the two, I carried out the following experiments:

Table 25. Crossings of Funa-wo with Mitsu-wo.

Exp. No.	Parents	Tetra-lobe		Tri-lobe		Imper-fectly paired		Paired tail total	Simple		Total	Investi-gator
			%		%		%			%		
0823	Shûkin (simple) × Shûkin (tri)	0	—	62	68.89	0	—	62	28	31.11	90	Toyama
2704	Wakin (tri) × Wakin (simple)	0	—	353	71.89	60	—	413	78	15.89	491	Matsui
2923	Ryûkin (tri) × Wakin (simple)	—	—	—	—	—	12.22	1349	5	0.37	1354	〃
32018	Wakin 3016 (simple × tri)	11	7.69	50	43.97	11	7.69	72	71	49.65	143	〃
32023	Wakin 3016 (simple) × Wakin (tri)	44	21.67	104	51.23	1	0.49	149	54	26.60	203	〃

Table 26.

Crossing of Funa-wo with Yotsu-wo.

Exp. No.	Parents	Tetra-lobe		Tri-lobe		Imper-fectly paired		Paired tail total	Simple		Total	Investi-gator
			%		%		%			%		
0806	Wakin (tetra) × Wakin (simple)	2	2.00	93	93.00	0	—	95	5	5.00	100	Toyama
1427	Wakin (simple) × Wakin (tetra)	419	58.44	211	29.43	78	10.88	708	9	1.25	717	〃
1426	Demekin (tetra) × Wakin(simple)	54	17.31	63	20.19	0	—	117	195	62.50	312	〃

Table 27.

Crossing of Imperfectly paired tail with Funa-wo.

Exp. No.	Parents	Tetra-lobe		Tri-lobe		Imper-fectly paired		Paired tail total	Simple		Total	Investi-gator
			%		%		%			%		
32019	Wakin (3016) imperfectly paired × simple	0	—	27	38.03	15	21.13	42	29	40.85	71	Matsui
32021	Wakin (3016) groove tail × simple tail	0	—	7	5.15	29	21.32	36	100	73.53	136	〃
32022	Wakin (3016) simple × imperfectly paired	3	1.72	58	33.33	36	20.69	97	77	44.25	174	〃

It seems to me that in these experiments, the different ways in which each character in F_1 appears is due to the fact that the Funa-wo of gold-fish are heterozygous and have several genes in them. But as no pure line race has yet been separated, I have made other experiments using the tail of Funa, which have the nearest relation to the Funa-wo of gold-fish, with the following results:

B. On the Crossing of Gold-fish with Funa.

Table 28.

F_1 from the crossing of Hiraki-wo of Gold-fish with Funa-wo of Funa.

Exp. No.	Parents	Paired tail	Simple tail	Total	Investigator
1616	Funa × Wakin (tri-lobed)	0	342	342	Toyama, Matsui
1618	Wakin (tri-lobed) × Funa	0	111	111	〃
18012	Wakin (tetra-lobed) × Funa	0	562	562	Matsui
2312	〃	0	98	98	〃
2405	〃	0	28	28	〃
2707	Wakin (tetra-lobed) × Funa	0	157	157	〃
32012	Funa × Wakin (tri-lobed)	0	720	720	〃
18022	Jikin (Kujaku-wo) × Funa	0	255	255	〃
18031	Funa × Ryûkin (tri-lobed)	0	1198	1198	〃
18032	Ryûkin (tri-lobed) × Funa	0	1625	1625	〃
21031	Ryûkin (Hiraki-wo) × Funa	0	255	255	〃
2313	Ryûkin (tetra-lobed) × Funa	0	23	23	〃
2717	〃	0	31	31	〃
2306	Demekin (tetra-lobed) × Funa	0	97	97	〃
2601	〃	0	34	34	〃

According to these experiments, unlike the case of the Funa-wo of gold-fish alone, F_1 are uniformly Funa-wo, and the Funa-wo of Funa is dominant over the Hiraki-wo of gold-fish. And since the caudal fin of the Wakin and Jikin are short, like those of Funa, I do not perceive any differences in the F_1. The F_1 of the Ryûkin or Demekin, however, have intermediate types with longer tails than those of Funa, as shown in the following Table:

Table 29.

Comparison of the ratio of caudal fin length to bodily length.

Race	Mean value	Race	Mean value
Funa	0.2690±0.0141	Ryûkin	0.7955±0.0085
Wakin	0.2610±0.0021	(Ryûkin × Funa) F_1	0.4100±0.0010
Demekin	0.5035±0.0051		

Table 30. Segregation of the caudal fin forms in F_2.

Exp. No.	Parents	Tetra-lobe	%	Tri-lobe	%	Imper-fectly paired	%	Paired tail total	Simple	%	Total
31008	2707 F_1	0	—	25	6.85	5	1.37	30	335	91.78	365
32003	〃	0	—	31	5.13	16	2.65	47	557	92.22	604
2318	18031 F_1	0	—	0	—	0	—	0	42	100.00	42
21301	18032 F_1	5	5.49	8	8.79	2	2.20	15	76	83.52	91
21306	〃	3	3.26	8	8.70	0	—	11	81	88.04	92
2915	2717 F_1	—	—	—	—	—	—	104	713	87.27	817
〃	〃	0	—	30	5.64	12	2.26	42	490	92.10	532
2916	〃	—	—	—	—	—	—	42	141	77.05	183
〃	〃	0	—	13	14.13	10	10.87	23	69	75.00	92
3012	〃	—	—	—	—	—	—	18	152	89.41	170
31009	〃	0	—	18	5.84	0	—	18	290	94.16	308
2503	2306 F_1	—	—	—	—	—	—	138	1560	91.87	1698
2607	〃	2	0.22	32	3.46	2	0.21	36	890	96.11	926
2608	〃	13	1.71	146	19.41	12	1.59	171	582	77.29	753
2710	〃	0	—	7	1.55	0	—	7	444	98.45	451
2801	2601 F_1	0	—	3	6.12	1	2.04	4	45	91.84	49

Table 31. Segregation of the length of caudal fin in F_2.

Exp. No.	Parents	Long tail						Short tail						Total
		Paired tail	%	Simple	%	Total	%	Paired tail	%	Simple	%	Total	%	
21301	18032 F_1	10	10.99	50	54.95	60	65.93	5	5.49	26	28.57	31	34.07	91
21306	〃	9	9.78	63	68.48	72	78.26	2	2.17	18	19.57	20	21.74	92
2915	2717 F_1	28	5.26	286	53.76	314	59.02	14	2.63	204	38.35	218	40.98	532
2916	〃	9	9.78	48	52.17	57	61.95	14	15.22	21	22.83	35	38.05	92
3012	〃	16	9.41	102	60.00	118	69.41	2	1.18	50	29.41	52	30.59	170
2710	2306 F_1	0	—	111	24.61	111	24.61	7	1.55	333	73.84	340	75.39	451

Table 32. F_3.

Exp. No.	Parents	Tetra-lobe		Tri-lobe		Imper-fectly paired		Paired tail total	Simple		Total
					%					%	
2919	2608 F_2 (tri × tri)	0	—	28	20.74	0	—	28	107	79.26	135
2920	2608 F_2 (simple × simple)	—	—	—	—	—	—	4	776	99.49	780
3014	〃	—	—	—	—	—	—	5	96	95.05	101
31001	〃	0	—	11	4.18	0	—	11	252	95.82	263

Table 33. Back cross. Crossing F_1 with Hiraki-wo.

Exp. No.	Parents	Tetra-lobe		Tri-lobe		Imper-fectly paired		Paired tail total	Simple		Total
			%		%		%			%	
32001	2707 F_1 × Wakin(tri)	1	0.14	191	26.83	51	7.16	243	469	65.87	712
21303	18032 F_1 × Ryûkin (tetra)	42	17.50	36	15.00	8	3.33	86	154	64.17	240
2913	Ryûkin (tri) × 2717 F_1	7	4.64	56	37.08	0	—	63	88	58.28	151
3013	Ryûkin (tetra) × 2717 F_1	—	—	—	—	—	—	239	366	60.50	605
〃	〃	71	16.59	64	14.95	0	—	135	293	68.46	428
2501	2306 F_1 × Demekin (tri)	—	—	—	—	—	—	735	2604	77.99	3339
2708	2306 F_1 × Demekin (tri)	15	3.65	10	2.43	0	—	25	386	93.92	411
2804	Demekin × 2601 F_1	—	—	—	—	—	—	1	168	99.41	169
2930	Demekin (tri) × 2601 F_1	0	—	56	19.05	0	—	56	238	80.95	294

Table 34. Back crossed F_1 with Funa-wo of Funa.

Exp. No.	Parents	Tetra-lobe		Tri-lobe		Imper-fectly paired		Paired tail total	Simple		Total
					%					%	
32002	2707F_1 × Funa	0	—	0	—	0	—	0	149	100	149
32004	2717F_1 × Funa	0	—	0	—	0	—	0	689	100	689
32005	Funa × 2717F_1	0	—	0	—	0	—	0	416	100	416
2709	2306F_1 × Funa	0	—	43	9.35	0	—	43	417	90.65	460

Table 35. Back cross F_2.

Exp. No.	Parents	Tetra-lobe	%	Tri-lobe	%	Imper-fectly paired	%	Paired tail total	Simple	%	Total
31011	2709 (simple tail self)	0	—	17	2.06	3	0.36	20	806	97.58	826
32006	2804 (simple tail self)	10	1.02	80	8.17	3	0.31	93	886	90.50	979
32007	〃	0	—	0	—	0	—	0	562	100.00	562
32014	2930 (tri-lobe self)	14	3.51	336	84.21	0	—	350	49	12.28	399

Unlike in the cases of gold-fish alone, the experiments, except in Nos. 2710, 2708, 2804, 2930, show a somewhat fixed segregation ratio, and it is quite clear that it is not a segregation of a monohybrid, but looks like a special segregation ratio of a dihybrid or polyhybrid. In these experiments the fish apparently had Funa-wo when they were young, although careful examinations of adults showed that some of these tails were provided with grooves as seen in the earlier stage of the Hiraki-wo, while some fish, as shown in Figs. 10 and 11 (Plate XII), had Funa-wo with the caudal peduncle inclining to one direction or curving to a certain extent. These tails showed certain segregation ratios. Whether these tails appeared as the result of influence of some genes in them that ought to have become Hiraki-wo, or whether they had certain acquired characters in the earlier period of their ontogeny, is a question that can be answered only after further experiments.

II. Experiments on the Anal fin.

A. On the Gold-fish alone.

Table 36. Single anal fin, self-breeding.

Exp. No.	Parents	Single	%	Double	%	No	Y	V	Total	Investi-gator
1421	Sanshoku-demekin(tri) × Sanshoku-demekin(tri)	467	31.11	1033	68.82	1	0	0	1501	Toyama
1424	Wakin(simple) × Wakin(simple)	1487	82.25	320	17.70	1	0	0	1808	〃
2713	Ranchû(tetra) × Ryûkin(tetra)	87	35.08	160	64.52	1	0	0	248	Matsui
2712	〃	104	23.64	336	76.36	0	0	0	440	〃
32019	Wakin(3016) imperfect tail × simple	67	94.37	4	5.63	0	0	0	71	〃
32021	Wakin(3016) groove tail × simple tail	134	98.53	2	1.47	0	0	0	136	〃
32023	Wakin(3016) simple × tri	169	83.25	34	16.75	0	0	0	203	〃

Table 37. Double anal fin, self-breeding.

Exp. No.	Parents	Single	%	Double	%	No	Y	V	Total	Investigator
1625	Kuro-demekin(tetra) × Kuro-demekin(tetra)	567	63.42	301	33.67	26	0	0	894	Toyama
18014	Wakin(tetra) × Wakin(tri)	229	18.74	989	80.95	1	2	1	1222	Matsui
18024	Jikin(Kujaku-wo) × Jikin(Kujaku-wo)	31	4.13	719	95.74	0	0	1	751	〃
18034	Ryûkin(tri) × Ryûkin(tri)	141	21.20	520	78.20	2	0	2	665	〃
18041	Demekin(tetra) × Wakin(tri)	491	36.91	1164	62.18	17	0	0	1872	〃
18042	Wakin(tetra) × Demekin(tetra)	488	16.89	2360	81.69	39	2	0	2889	〃
18043	Demekin(tetra) × Demekin(tetra)	231	29.69	537	69.02	3	2	5	778	〃
18044	Wakin(tetra) × Wakin(tri)	392	16.16	2003	82.56	1	13	17	2426	〃
2604	Kuro-demekin(tetra) × Sanshoku-demekin(tri)	98	65.33	51	34.00	0	0	1	150	〃
2716	Ryûkin(tetra) × Wakin(tetra)	8	1.45	544	98.55	0	0	0	552	〃
2715	Ryûkin(tri) × Ranchû(tetra)	83	18.82	356	80.73	2	0	0	441	〃

Table 38. Double anal fin F_2.

Exp. No.	Parents	Single	%	Double	%	No	Y	V	Total
21401	1804F_1 double self	31	19.87	120	76.92	0	3	2	156
21402	〃	8	25.00	24	75.00	0	0	0	32
22402	〃	23	17.69	104	8.00	0	1	2	130
2211	〃	37	30.83	81	67.50	0	1	1	120
2912	2716F_1 double self	10	7.14	130	92.86	0	0	0	140
3011	〃	65	10.42	559	89.58	0	0	0	624
21403	1804 (double × single)	34	41.46	48	58.54	0	0	0	82
21404	1804 (double × Y)	18	28.13	46	71.87	0	0	0	64

Table 39. Back cross.

Exp. No.	Parents	Single		Double		No	Y	V	Total
			%		%				
21407	1804 F_1 (double) × 18044 (double)	7	10.29	61	89.71	0	0	0	68
22407	〃	118	30.64	264	68.57	0	0	3	385
21416	Wakin (double) × 1804F_1 (double)	48	30.97	107	69.03	0	0	0	155
21413	1804 F_1 (double) × Demekin (single)	7	15.22	39	84.78	0	0	0	46

Table 40. Crossing single anal fin with double anal fin.

Exp. No.	Parents	Single		Double		No	Y	V	Total	Investigator
			%		%					
1423	Demekin(tri) × Ranchû(tri)	181	43.10	239	56.90	0	0	0	420	Toyama
2701	Wakin(simple) × Wakin(simple)	440	93.22	32	6.78	0	0	0	472	Matsui

Table 41. F_2.

Exp. No.	Parents	Single		Double		No	Y	V	Total	Investigator
			%		%					
1641	1423 double self	79	47.31	14	8.38	74	0	0	167	Toyama, Matsui
1642	1423 single self	80	66.67	37	30.83	3	0	0	120	〃
1643	〃	101	77.69	25	19.23	4	0	0	130	〃
2924	2701 single self	373	75.35	122	24.65	0	0	0	495	Matsui
2925	2701 double × single	175	76.09	55	23.91	0	0	0	230	〃

Table 42. F_3.

Exp. No.	Parents	Single		Double		No	Y	V	Total
			%		%				
32011	2925 single self	84	57.53	62	42.47	0	0	0	146
32009	single × 2924 single	541	62.26	328	37.74	0	0	0	869

Table 43. Double × Single.

Exp. No.	Parents	Single	%	Double	%	No	Y	V	Total
2704	Wakin tri × simple	361	73.52	130	26.48	0	0	0	491
2922	Wakin tri × tetra	181	52.16	166	47.84	0	0	0	347
3017	2711 (tsumami-wo) × Wakin (imperfect paired)	78	39.80	118	60.20	0	0	0	196

Table 44. F_2.

Exp. No.	Parents	Single	%	Double	%	No	Y	V	Total
32024	3017 tri single self	100	69.44	44	30.56	0	0	0	144
32025	〃	153	86.93	23	13.07	0	0	0	176

Table 45. No anal fin × Single.

Exp. No.	Parents	Single	%	Double	%	No	Y	V	Total
21415	18041 (tetra) × Wakin (tetra)	4	4.44	86	96.56	0	0	0	90

Table 46. F_2 of Exp. No. 21415.

Exp. No.	Parents	Single	%	Double	%	No	Y	V	Total
2711	21415 single × single	26	24.07	82	75.93	0	0	0	108

Table 47. F_3.

Exp. No.	Parents	Single	%	Double	%	No	Y	V	Total
2917	2711 double self	122	61.31	77	38.69	0	0	0	199
31013	〃	42	7.89	487	91.54	3	0	0	532

Table 48. V-shaped anal fin × Single.

Exp. No.	Parents	Single	%	Double	%	No	Y	V	Total
23018	Wakin (3016) simple-V × tri-single	94	6.573	49	34.27	0	0	0	143

Table 49. Double × Y-shaped anal fin.

Exp. No.	Parents.	Single	%	Double	%	No	Y	V	Total
2206	Demekin (tetra-double) × Wakin (tri)	226	62.09	114	31.32	24	0	0	364

Table 50. F_2 of Exp. No. 2206.

Exp. No.	Parents	Single	%	Double	%	No	Y	V	Total
2719	2206 tri single self	30	10.20	264	89.80	0	0	0	294

Table 51. F_3 of Exp. No. 2206.

Exp. No.	Parents	Single	%	Double	%	No	Y	V	Total
2927	2719 double self	32	72.73	12	27.27	0	0	0	44

Table 52. F_4 of Exp. No. 2206.

Exp. No.	Parents	Single	%	Double	%	No	Y	V	Total
31004	2927 double self	1	0.62	161	99.38	0	0	0	162

Although the foregoing experiments were not conducted specially for the present purpose, but are the outcome of certain other experiments with different objects in view, yet from them we arrive at the rough conclusion that, as in the case of the caudal fin of gold-fish, the segragation of each form is not constant, thereby producing sometimes quite contradictory examples.

B. On the Crossing of Gold-fish with Funa.

Table 53. Single anal fin of gold-fish × Single anal fin of Funa.

Exp. No.	Parents	Single		Double		Total
2312	Wakin (tri) × Funa	98	100%	0	—	98
2405	Wakin (tetra) × Funa	28	100	0	—	28
32012	Funa × Wakin (tri)	720	100	0	—	720

Table 54. Double anal fin of gold-fish × Single anal fin of Funa.

Exp. No.	Parents	Single		Double		Total
18012	Wakin (tetra) × Funa	562	100%	0	—	562
2707	Wakin (tri) × Funa	157	100	0	—	157
18031	Funa × Ryûkin (tri)	1198	100	0	—	1198
18032	Ryûkin (tri) × Funa	1925	100	0	—	1625
21031	Ryûkin (tetra) × Funa	255	100	0	—	255
2717	〃	31	100	0	—	31
2306	Demekin (tetra) × Funa	97	100	0	—	97
2601	〃	34	100	0	—	34

Unlike in the case of experiments on gold-fish alone, the mono-anal fin of Funa are clearly dominant over the di-anal fin of gold-fish.

Table 55. F_2 from crossing di-anal fin of gold-fish with mono-anal fin of Funa.

Exp. No.	Parents	Single		Double		No.	Y	V	Total
31008	2707 F_1	344	92.23%	29	7.77%	0	0	0	373
32003	〃	587	98.00	15	1.66	2	0	0	604
21301	18032 F_1	80	87.91	10	10.99	0	0	1	91
21306	〃	88	95.65	4	4.35	0	0	0	92
2915	2717 F_1	497	93.42	35	6.58	0	0	0	532
2916	〃	86	91.49	6	6.38	2	0	0	94
3012	〃	169	99.41	1	0.59	0	0	0	170
31009	〃	295	95.78	13	4.22	0	0	0	308
2318	18031 F_1	42	100.00	0	—	0	0	0	42
2607	2306 F_1	895	96.65	31	3.35	0	0	0	926
2608	〃	647	85.92	106	14.08	0	0	0	753
2710	〃	440	97.56	11	2.44	0	0	0	451
2801	2601 F_1	48	97.96	1	2.04	0	0	0	49

Table 56. Back cross.

Exp. No.	Parents	Single	%	Double	%	No	Y	V	Total
32001	2707 F_1 × Wakin (tri-double)	540	75.84	172	24.16	0	0	0	712
3013	Ryûkin (tetra-double) × 2717 F_1	280	65.42	147	34.35	1	0	0	428
2913	2716 (tri-double) × 2717 F_1	101	66.89	50	33.11	0	0	0	151
2708	Demekin (tri-double) × 2306 F_1	249	60.58	162	39.42	0	0	0	411
2804	Demekin (tetra-double) × 2601 F_1	168	99.41	1	0.59	0	0	0	169
31002	〃	26	35.14	48	64.86	0	0	0	74
2930	Kuro-demekin (tri-double) × 2601 F_1	258	87.16	36	12.16	2	0	0	296
32002	2707 F_1 × Funa	149	100.00	0	—	0	0	0	149
32004	2717 F_1 × Funa	689	100.00	0	—	0	0	0	689
32005	Funa × 2717 F_1	416	100.00	0	—	0	0	0	416
2709	2306 F_1 × Funa	431	93.70	29	6.30	0	0	0	460

Table 57. Back cross F_2.

Exp. No.	Parents	Single	%	Double	%	No	Y	V	Total
2920	2608 (simple-single self)	778	99.74	2	0.26	0	0	0	780
3014	〃	95	94.06	6	5.94	0	0	0	101
31001	〃	238	90.49	25	9.51	0	0	0	263
2921	2608 (tri-single × simple-single)	215	77.62	62	22.38	0	0	0	277
2919	2608 (imperfect-single × double)	115	85.19	20	14.81	0	0	0	135

As shown in the 240 examples in the foregoing 57 tables, the inheritance of the caudal and anal fins are very inconstant, showing unstable segregation of independent inheritance.

Now the caudal and the anal fins of ordinary fish are what have developed from the same postanal fold, and since in gold-fish these two kinds of fins are paired fins that developed from paired folds[2], the paird caudal fins and the double anal fins are genetically related, and may be considered as having a linkage inheritance. I shall, therefore, consider next cases of combinations of the two.

III. Experiments on the Combinations of Caudal and Anal fins.

A. On the Gold-fish alone.

a) Experiments on Hiraki-wo and double anal fin, self-breeding.

F_1 Generation.

Table 58.

Exp. No.	Parents	Simple-single	%	Simple-double	%	Paired-single	%	Paired-double	%	Others	Total
1425	Kuro-demekin (tetra-double) × Kuro-demekin (tetra double)	0	—	0	—	567	63.42	301	33.67	No 26	894
18014	Wakin (tetra-double) × Wakin (tri-double)	1	0.08	1	0.08	228	18.72	988	81.12	2	1218
18041	Demekin (tetra-double) × Wakin (tri-double)	0	—	0	—	691	36.91	1164	62.18	17	1872
18042	Wakin (tetra-double) × Demekin (tetra-double)	0	—	0	—	488	16.89	2362	81.76	39	2889
18043	Demekin (tetra-double) × Demekin (tetra-double)	0	—	0	—	231	29.69	544	69.92	3	778
18044	Wakin (tetra-double) × Wakin (tri-double)	7	0.29	4	0.16	385	15.87	2029	83.64	1	2426
18034	Ryûkin (tri-double) × Ryûkin (tri-double)	0	—	1	0.15	141	21.20	521	78.35	2	665
2716	Ryûkin (tetra-double) × Wakin (tetra-double)	1	0.18	1	0.18	7	1.27	543	98.37	0	552

F_2 Generation.

1) Hiraki-wo and double anal fin, self-breeding.

Table 59.

Exp. No.	Parents	Simple-single	%	Simple-double	%	Paired-single	%	Paired-double	%	Others	Total
21401	18041 F_1 (tetra-double)	0	—	0	—	31	19.87	125	80.13	0	156
21402	〃	0	—	0	—	8	25.00	24	75.00	0	32
22402	〃	0	—	2	1.54	23	17.69	105	80.77	0	130
2211	〃	0	—	0	—	36	30.00	83	69.17	No 0	120
2912	2716 F_1 (tri-double × tetra-double)	1	0.71	10	7.14	9	6.43	120	85.71	0	140
3011	〃	18	2.88	26	4.17	47	7.53	533	85.42	0	624

2) Hiraki-wo and double × Hiraki-wo and single.

Table 60.

Exp. No.	Parents	Simple-single	%	Simple-double	%	Paired-single	%	Paired-double	%	Total
21402	1804 F_1 (imperfect paired)	1	3.12	0	—	21	65.63	10	31.25	32
21403	1804 F_1 (tetra × tri)	0	—	0	—	34	41.46	48	58.54	82

Back crossing.

1) F_1 Hiraki-wo and double × Hiraki-wo and double.

Table 61.

Exp. No.	Parents	Simple-single	%	Simple-double	%	Paired-single	%	Paired-double	%	Total
21407	1804 F_1 (tetra-double) × Wakin (tetra-double)	0	—	1	1.47	7	10.29	60	88.24	68
22407	〃	15	3.90	6	1.56	103	26.75	261	67.79	385
21416	Wakin (tetra-double) × 1804 F_1 (tri-double)	1	0.65	0	—	47	30.32	107	69.03	155

2) F_1 Hiraki-wo, double × Hiraki-wo, single.

Table 62.

Exp. No.	Parents	Simple-single	%	Simple-double	%	Paired-single	%	Paired-double	%	Total
21414	Demekin (tetra-single) × 1804 (tetra-double)	4	10.52	0	—	23	60.53	11	28.95	38
21406	Demekin (tri-single) × 1804 (tetra-double)	7	15.91	3	6.82	12	27.27	22	50.00	44
21412	Demekin (tri-single) × 1804 (tri-double)	6	4.80	1	0.80	54	43.20	64	51.20	125
21413	1804 (tetra-double) × Wakin (tetra-single)	0	—	0	—	9	19.57	37	80.43	46

3) F_1 Hiraki-wo and single × Hiraki-wo and single.

Table 63.

Exp. No.	Parent	Simple-single	%	Simple-double	%	Paired-single	%	Paired-double	%	Others	Total
21405	1804 F_1 (tetra-single) × Demekin (tri-single)	2	1.15	1	0.57	49	28.16	122	70.11	0	174
21411	1804 F_1 (tetra-single) × Demekin (tri-single)	0	—	0	—	51	22.47	175	77.09	No 1	227

4) F_1 Hiraki-wo, single × Hiraki-wo, double.

Table 64.

Exp. No.	Parents	Simple-single		Simple-double		Paired-single		Paired-double		Total
			%				%		%	
21409	Demekin (tetra-double) × 1804 F_1 (tetra-single)	1	0.61	0	—	5	3.07	157	96.32	163

b) Crossings of Hiraki-wo and double anal fin with Hiraki-wo and single anal fin.

F_1 Generation.

Table 65.

Exp. No.	Parents	Simple-single		Simple-double		Paired-single		Paired-double		Total
			%		%		%		%	
3017	2711 (Tsumami-wo-double) × Wakin (imperfect-single)	19	9.69	11	5.61	59	30.10	107	54.59	196

F_2 Generation.

Table 66.

Exp. No.	Parents	Simple-single		Simple-double		Paired-single		Paired-double		Total
			%		%		%		%	
32024	3017 (tri-single)	56	38.89	9	6.25	44	30.56	35	24.31	144
32025	〃	111	63.07	15	8.52	42	23.86	8	4.55	176

c) Crossings of Hiraki-wo, double anal fin with Funa-wo, single anal fin.

Table 67.

Exp. No.	Parents	Simple-single		Simple-double		Paired-single		Paired-double		Total
			%		%		%		%	
2704	Wakin (tri-double) × Wakin (simple-single)	74	15.07	4	0.81	287	58.45	126	25.66	491

d) Crossings of Hiraki-wo, single anal fin with Funa-wo, double anal fin.

Table 68.

Exp. No.	Parents	Simple-single		Simple-double		Paired-single		Paired-double		Total
			%		%		%		%	
32022	Wakin (3016) (simple-double × imperfect-single)	64	36.78	13	7.47	59	33.91	38	21.84	174

e) Crossings of Hiraki-wo, single anal fin with Funa-wo, single anal fin.

Table 69.

Exp. No.	Parents	Simple-single		Simple-double		Paired-single		Paired-double		Total
			%		%		%		%	
32019	Wakin (3016) imperfect-single × simple-single	30	42.25	0	—	37	52.11	4	5.63	71
32021	〃 groove-single × simple-single	100	73.53	0	—	34	25.00	2	1.47	136
32023	〃 groove-single + tri-single	52	25.62	2	0.98	117	57.64	32	15.76	203

f). Funa-wo, single anal fin, self-breeding.

Table 70.

Exp. No.	Parents	Simple-single		Simple-double		Paired-single		Paired-double		Total
			%		%		%		%	
1424	Wakin	1070	59.31	1	0.06	414	22.95	319	17.68	1804

g) Crossings of Funa-wo, single anal fin with Funa-wo, double anal fin.

F_1 Generation.

Table 71.

Exp. No.	Parents	Simple-single		Simple-double		Paired-single		Paired-double		Total
			%		%		%		%	
2701	Wakin	114	24.15	0	—	326	69.07	32	6.78	472

F_2 Generation.

1) F_1 Funa-wo and single anal fin, self-breeding.

Table 72.

Exp. No.	Parents	Simple-single		Simple-double		Paired-single		Paired-double		Total
			%		%		%		%	
2924	2701 F_1	278	56.16	27	5.45	95	19.19	95	19.19	495

2) F_1 Hiraki-wo, double anal fin crossed with Hiraki-wo, single anal fin.

Table 73.

Exp. No.	Parents	Simple-single		Simple-double		Paired-single		Paired-double		Total
			%		%		%		%	
2925	2701 F_1 (double × single)	19	9.69	11	5.61	59	30.10	107	54.59	196
3017	〃	68	29.57	5	2.17	107	46.52	50	21.74	230

F_3 Generation.

Table 74.

Exp. No.	Parents	Simple-single		Simple-double		Paired-single		Paired-double		Total
			%		%		%		%	
32011	2925 (simple-single self)	22	15.07	1	0.68	62	42.47	61	41.78	146

These experiments show that certain combinations of the same material give different results—a phenomenon that calls for carefuly study and that will probably prove a difficult problem to solve.

I tried 8 cases of 7 combinations, but in an experiment of this kind more than 16 cases of 10 combinations are required even for F_1 alone and what is more, a very wide range of cases is necessary for F_2 and the back crossings. I therefore believe that it is still premature to draw any conclusion whatsoever.

B. On the Crossing of Gold-fish with Funa.

a) Crossings of the Hiraki-wo, dianal fin of gold-fish with the Funa-wo, monoanal fin of Funa.

F_1 Generation.

Table 75.

Exp. No.	Parents	Simple-single		Simple-double		Paired-single		Paired-double		Total
18012	Wakin (tetra-double) × Funa	502	100%	0	—	0	—	0	—	502
2707	Funa × Wakin (tri-double)	157	100	0	—	0	—	0	—	157
18032	Ryûkin (tri-double) × Funa	1625	100	0	—	0	—	0	—	1625
2313	Ryûkin (tetra-double) × Funa	23	100	0	—	0	—	0	—	23
2717	〃	31	100	0	—	0	—	0	—	31
2306	Demekin (tetra-double) × Funa	97	100	0	—	0	—	0	—	97
2601	〃	34	100	0	—	0	—	0	—	34

F_2 Generation.

Table 76.

Exp. No.	Parents	Simple-single	%	Simple-double	%	Paired-single	%	Paired-double	%	Total
31008	2707 F_1	325	84.64	10	2.60	19	4.95	30	7.81	384
32003	〃	552	91.69	4	0.66	35	5.81	11	1.83	602
21301	18032 F_1	74	81.32	2	2.20	7	7.69	8	8.79	91
21306	〃	80	86.96	1	1.09	8	8.70	3	3.26	92
2915	2717 F_1	483	90.79	7	1.32	14	2.63	28	5.26	532
2916	〃	69	75.00	0	—	17	18.48	6	6.52	92
3012	〃	152	89.41	0	—	17	10.00	1	0.59	170
31009	〃	285	92.53	5	1.62	10	3.25	8	2.60	308
2607	2306 F_1	885	95.57	5	0.54	10	1.08	26	2.81	926
2608	〃	570	75.70	12	1.59	77	10.23	94	12.48	753
2801	2601 F_1	45	91.84	0	—	3	6.12	1	2.04	49

The segregation in F_2 does not show the normal ratio of a dihybrid. It is noticeable that in the same combinations the segregation ratios are very unstable and appear to produce linkages.

Back crossing.

1) F_1 × Hiraki-wo, dianal fin of gold-fish.

Table 77.

Exp. No.	Parents	Simple-single	%	Simple-double	%	Paired-single	%	Paired-double	%	Total
21303	18032 F_1 × Ryûkin (tetra-double)	153	63.75	1	0.42	13	5.42	73	30.42	240
32001	2707 F_1 × Wakin (tri-double)	447	62.78	22	3.09	93	13.06	150	21.07	712
2930	Demekin (tri-double) × 2601 F_1	238	80.95	0	—	20	6.80	36	12.24	294
2708	2306 F_1 × Demekin (tri-double)	245	59.61	141	34.31	4	0.97	21	5.11	411
3013	Ryûkin (tetra-double) × 2717 F_1	262	61.36	31	7.26	18	4.22	116	27.17	427
2913	2716 (tri-double) × 2717 F_1	88	58.28	0	—	13	8.61	50	33.11	151

In these experiments, F_1 was back-crossed with the Hiraki-wo and dianal fins, which are double recessive, the crossing-over percentages being as shown in the following Table.

Table 78.

Exp. No.	Funa-wo & dianal finned	Hiraki-wo & monoanal finned	Total
	%	%	%
21303	0.42	5.42	5.84
32001	13.09	13.06	16.15
2930	0	6.80	6.80
2708	34.31	0.97	35.28
3013	7.26	4.22	11.48
2913	0	8.61	8.61

The remarkable differences in the numerical values is a phenomenon worthy of careful study.

2) $F_1 \times$ Funa-wo, monoanal fin of Funa.

Table 79.

Exp. No.	Parents	Simple-single		Simple-double		Paired-single		Paired-double		Total
32002	2707 $F_1 \times$ Funa	149	100%	0	—	0	—	0	—	149
32004	2717 $F_1 \times$ Funa	689	100	0	—	0	—	0	—	680
32005	Funa $\times$ 2717 F_1	416	100	0	—	0	—	0	—	416

F_3 Generation.

1) Funa-wo and monoanal fin, self-breeding.

Table 80.

Exp. No.	Parents	Simple-single		Simple-double		Paired-single		Paired-double		Tatol
			%		%		%		%	
2920	2608 F_2	776	99.49	0	—	2	0.26	2	0.26	780
3014	〃	94	93.07	2	1.98	1	0.99	4	3.96	101
31001	〃	232	88.21	20	7.60	6	1.90	5	1.90	263

2) Hiraki-wo and monoanal fin $\times$ Hiraki-wo and dianal fin.

Table 81.

Exp. No.	Parents	Simple-single		Simple-double		Paired-single		Paired-double		Total
			%		%		%		%	
2919	2608 F_2	92	68.15	15	11.11	5	3.70	23	17.04	135

b) Crossings of Hiraki-wo, monoanal fin of gold-fish with the Funa-wo, monoanal fin of Funa.

Table 82.

Exp. No.	Parents	Simple-single		Simple-double		Paired-single		Paired-double		Total
			%							
2312	Wakin (tetra-single) × Funa	98	100 00	0	—	0	—	0	—	98
2405	〃	28	100.00	0	—	0	—	0	—	28
32012	Funa × Wakin (tri-single)	720	100.00	0	—	0	—	0	—	720

The foregoing details are the results of my studies so far, but, as I have said before, they are still far from conclusive. Further experiments are needed. From knowledge available thus far, it is my belief thet the differences in the segregation ratios from the same combinations are the results of complex inheritance. It may be legitimate to suppose that in the self-breedings of the Hiraki-wo and dianal fin, the Funa-wo and monoanal fin may appear by reverse mutation. It may also be supposed that divergent appearances of the segregation ratio in the same crossing is not caused by the fact that every type of fin is not a homozygote, but that there may be a sex-linkage. As to Funa, the males greatly outnumber the females; according to investigations made near Toyohashi[4], there were 100 females to 13.6 males, while near Sendai, according to Mr. Sasaki (1926)[6], there were 100 females to 12.9 males. Environment seems to influence considerably the differences in the segregation ratios, for the breeding season of gold-fish is generally May to June, when the temperature of the water ranges from 12°C to 30°C; and since the period of incubation depends on the temperature of the water, the question of cytoplasmic influence or inheritance is also one that requires full consideration.

Summary

1. The Hiraki-wo of gold-fish are on the whole homozygous, but sometimes they segregate a small number of Funa-wo. The Funa-wo, which is heterozygous, seems to consist of several genes.

2. The Funa-wo of gold-fish and Funa have quite a different hereditary relation to the Hiraki-wo of gold-fish. The Funa-wo of Funa is dominant over the Hiraki-wo, and we see from the segregation of the F_2

that these are not monohybrid. The length of a caudal fin is an intermediate hybrid.

3. It seems that the anal fins of gold-fish show complex segregation, and have complex relations with respect to inheritance. In the crossings of the double anal fin with the single one of Funa, the latter is dominent over the former, and when viewed in the light of segregations of the next generation, shows that they are not mono-hybrid.

4. According to the results of the crossing of combinations of the caudal fin and the anal ones, these two have some linkage.

5. The Funa-wo of gold-fish and those of Funa are believed to have the same forms, but it appears that the two have different gene constitutions, the same being true also in the case of the single anal fin.

March, 1933.

THE PISCICULTURAL BRANCH OF THE IMPERIAL
FISHERIES EXPERIMENT STATION.
TOYOHASHI, JAPAN.

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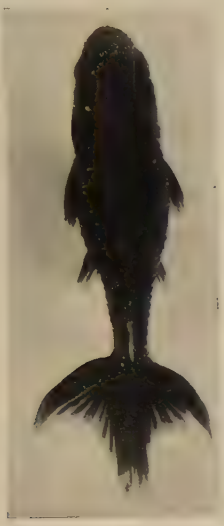
Explanation of Figures. (Plates XI, XII).

Fig. 1. Mitsu-wo (Wakin)
Fig. 2. Sakura-wo (Wakin)
Fig. 3. Yotsuo-wo (Wakin)
Fig. 4. Tsumami-wo (Watonai)
Fig. 5. A form of imperfectly paired tail (Watonai)
Fig. 6. Kujaku-wo (Jikin)
Fig. 7. Grooved caudal fin.
Fig. 8. Apparently a Funa-wo, which is slightly grooved, and has dianal fin.
Fig. 9. Funa-wo.
Fig. 10. Funa-wo with the caudal peduncle inclined in one direction.
Fig. 11. Ibid.
Fig. 12. A form of imperfectly paired tail.
Fig. 13. Double anal fin.
Fig. 14. Yotsu-wo and single anal fin.
Fig. 15. Mitsuo-wo and double anal fin.
Fig. 16. Funa-wo and double anal fin.

PL. XI.



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PL. XII.

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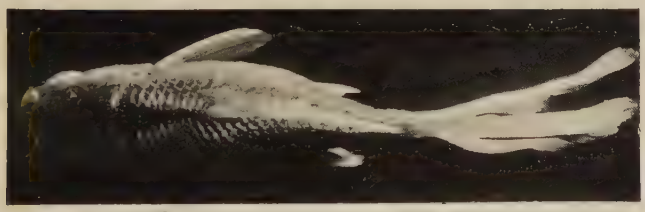

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Chemical Study on Protamine VI.

1) Acid hydrolysis of salmine.

Prof. Makoto Yamagawa NG. NH. and Tanzô Nishizawa.

(Received May 20, 1933)

There are so many works on the investigations in the structure of protein, but owing to the variety and multifariousness of its units and because of the complex construction, none of them, it seems, have arrived at any satisfactory conclusion, though they may be said to have thrown some light upon the obscurity. Among them, Kossel(1) and other authors published several papers on the hydrolysis of salmine. As the salmine is the first member to be found among this group and is the simplest one of the protein, its investigation is relatively in detail. At present, the aminoacids as its unit have been fully explained in their kinds and amounts, and so the study of the structure of salmine seems to have made a considerable progress.

The essential points of the works hitherto done on salmine structure, are as follows:—

The salmine which Miescher discovered, had been investigated by Kossel and his pupils, and their study threw much more light on the protamine chemistry by hydrolysing salmine and they made $(C_{98}H_{186}N_{54}O_{21})_x$ for the salmine formula. Moreover, Kossel analysed that hydrolysate and certified that the salmine consists of 2 mol. arginine, 3 mol. proline, 2 mol. serine and 1 mol. valine, that is, it is in combination of one monoaminoacid for each two mols. of arginine, and it is said that the ratio of aminoacid in protone is the same as in protamine. From experimental results, Kossel thought that there is peptide-linkage in the molecule of protamine, and proposed the following general scheme:

(1) aam—aam—aam—... (2) ama—ama—ama—...

But this scheme could not be admitted since Nelson-Gerhardt(2) proved the existence of monoaminoacid-peptide.

Also, Gross(3) proved that the monoaminoacid-peptide is in clupein. As for the existence of peptide, Kossel and Staudt(4) isolated the arginyl-

arginide from salmine and also proved that arginine combines directly each other in part in the molecule of salmine. By hydrolysing nitrosalmine, Kennaway(5) asserted that(6) guanidine-radical of arginine must be in free in molecule.

Though Taylor proposed for salmine the following formula, but it is only hypothetical being suggested by the construction of kyrine.

$$\left\{\begin{matrix}\text{arginine}\\\text{serine}\\\text{arginine}\end{matrix}\right\}\left\{\begin{matrix}\text{arginine}\\\text{serine}\\\text{arginine}\end{matrix}\right\}\left\{\begin{matrix}\text{arginine}\\\text{proline}\\\text{arginine}\end{matrix}\right\}\left\{\begin{matrix}\text{arginine}\\\text{proline}\\\text{arginine}\end{matrix}\right\}\left\{\begin{matrix}\text{arginine}\\\text{proline}\\\text{arginine}\end{matrix}\right\}\left\{\begin{matrix}\text{arginine}\\\text{valine}\\\text{arginine}\end{matrix}\right\}$$

Kossel, however, did not think clupein as single protamine, recently, Felix and his co-workers(7, 8, 9, 10, 11, 12) divided it into four fractions in the form of methylesterhydrochloride, and explained the mode of linkage of free carboxyl group in clupein, and moreover, proposed the scheme of m-a-a- for their clupein. They assumed that, in protone of clupein, mono-aminoacid is at aminoend of tripeptide, by isolating several dipeptides in partial hydrolysis.

We have described only an outline of the Felix works, as the purpose of this present work is on the structure of salmine and it is doubtful whether either our salmine or A_1, A_2 after Felix is the same in structure.

First of all, by certifying the different degrees of the resistance of aminoacids contained in salmine towards hydrolytic agents, we attempted to get some knowledge about the linkage of units in salmine molecule. We have, therefore, carried on this investigation, begining from the simplest protein, protamine, as the first steps. We are now going to make a report on the part of the results we have reached, and this will be followed by a second.

EXPERIMENTAL PART.

[I] Material.

The material used was salmine sulphate, isolated and purified by Kossel's method from the sperm of Japanese salmon, *Oncorhynchus keta*. (1) Identification of salmine sulphate. We have started to see whether the material we made use of, that is, salmine sulphate, is identical with that of the European species, namely, is the same as Kossel's.

a) Test of hydrolysed products. (The qualitative analysis for the hydrolysate was undertaken after usual method.)

i) The biuret, Millon, diazo- and dimethylaminobenzaldehyde- reactions

are all negative, but ii) it gives strong the Sakaguchi reaction. iii) In free state, there is no sulphur.

b) Properties of salmine sulphate. This sulphate is hygroscopic, white, and of amorphus powder, whose base is strong alkaline and uncoagulable in heat in the state of aqueous solution, and very soluble in water, but insoluble in alcohol and ether. As described above, it does not give other reactions, but the biuret and Sakaguchi reactions. It is precipitated by phosphotungstic acid, phosphomolybdic acid, mercuric chloride, potassium ferrocyanide, tannin, potassium chromate, and sulfosalicylic acid, but neither by silver nitrate nor by potassium-iodine-iodide, and is salted out from solution by sodium chloride and ammonium sulphate.

For the determination of specific rotatory power, 0,4660 gm of this sulphate was dissolved in distilled water, the total volume being 100 ccm. and observed through a tube 20 cm. long, and at the same time, the pH value was also determined.

$$\alpha = -0{,}38^\circ; \qquad \frac{-0{,}38 \times 100}{2 \times (0{,}4660 \div 2)}, \qquad [\alpha]_D^{24} = -81{,}53$$

$$\mathrm{pH} = \frac{0{,}5450 - 0{,}2458}{0{,}057} = 5{,}24$$

Index of refraction in oily state was estimated with Abbe's instrument to be, 1,442.

c) Elementary analysis of salmine sulphate. The purified sulphate was dried in an air bath to get constant weight, and analysed with following results:

Table I.

	Found		
	I	II	Average
Carbon	37,02 %	36,97 %	37,02 %
Hydrogen	6,63 %	6,59 %	6,61 %
Nitrogen	24,69 %	24,65 %	24,67 %
Sulphur	7,16 %	7,17 %	7,17 %

d) Elementary analysis of salmine platinic chloride. It was prepared from the sulphate by Goto's method(15) and analysed by the ordinary method.

Table II.

	Found		
	I	II	Average
Carbon	23,92 %	23,91 %	23,92 %
Hydrogen	4,29 %	4,32 %	4,31 %
Nitrogen	15,10 %	15,51 %	15,44 %
Platinum	24,33 %		24,33 %
Chlorine	25,10 %	25,12 %	25,11 %

(2) Distribution of nitrogen in salmine sulphate. The nitrogen distribution was carried out by Van Slyke's method and, at the same time, by using flavianic acid(16). But nitrogen of monoaminoacids was estimated by the nitrogen contained in the part separated by means of solubility in ethyl and methyl alcohol.

(3) Identification of the individual monoaminoacids. There are three portions in the monoaminoacid-fraction,—(i) one soluble in ethyl alcohol, (ii) one insoluble in ethyl alcohol, but soluble in methyl alcohol, (iii) one insoluble in both. These are derived to copper salt, and we analysed nitrogen and copper respectively.

Copper salt of ethyl alcohol-soluble portion:

Sample		Found	Calculated for $C_{10}H_{16}N_2O_4Cu$
0,0928 gm	N/10 Acid=6,4 cc	N = 9,66%	N = 9,60%
0,0550 gm	CuO=0,0150 gm	Cu=21,82%	Cu=21,78%

Copper salt of ethyl alcohol-insoluble but methyl alcohol-soluble portion:

Sample		Found	Calculated for $C_{10}H_{20}N_2O_4Cu$
0,1315 gm	N/10 Acid=9,0 cc	N = 9,58%	N = 9,47%
0,0694 gm	CuO=0,0187 gm	Cu=21,47%	Cu=21,49%

Copper salt of ethyl and methyl alcohol-insoluble portion:

Sample		Found	Calculated for $C_6H_{12}N_2O_6Cu$
0,0556 gm	N/10 Acid=4,1 cc	N =10,32%	N =10,31%
0,0803 gm	CuO=0,0233 gm	Cu=23,16%	Cu=23,40%

Table III.
Distribution of nitrogen.

	Experiment VI$_2$					Experiment VII				
	As sulphate	As free protamine	% of total N	N % in filtrate	Gm.	As sulphate	As free protamine	% of total N	N % in filtrate	Gm.
Total nitrogen	24,62	31,54	100,00			24,62	31,54	100,00		
N removed with Ba sulphate	0,18	0,23	0,73			0,19	0,24	0,76		
Nitrogen in filtrate	24,44	31,31	99,27	100,00		24,43	31,30	99,24	100,00	
Arginine-N	21,80	27,93	88,55	89,20	86,79	21,78	27,90	88,46	89,14	86,70
Total N in filtrate from silver-baryt	2,64	3,38	10,72	10,80		2,65	3,40	10,78	10,86	
Proline-N	1,20	1,54	4,88	4,92	12,65	1,24	1,59	5,04	5,08	13,06
Valine-N	0,45	0,58	1,84	1,85	4,85	0,46	0,59	1,87	1,88	4,93
Serine-N (caled. with diff. of total N in filtrate from Ag-baryt and N of (proline-N +valine-N)	0,99	1,27	4,00	4,03	9,53	0,95	1,22	3,87	3,90	9,15

Calculating these results, we compared the number of units in salmine with those numbers obtained by Kossel(13) and Taylor(19).

Table IV.

	Salmine taken from Japanese salmon		Salmine taken from Rhein salmon by Kossel 1904.(13)		Salmine taken from Quinnant salmon by Taylor 1908–09.(19)	
	N% as free protamine	No. of mol.	N% as free protamine	No. of mol.	N% as free protamine	No. of mol.
Arginine	27,92	12	28,13	14	29,51	12
Proline	1,57	3	1,34	3	1,31	2
Valine	0,59	1	0,51	1	0,63	1
Serine	1,25	2	1,04	2	1,16	2

Table IV a.

Arginine	$C_6H_{14}N_4O_2$	× 12	=	$C_{72}H_{168}N_{48}O_{24}$
Proline	$C_5H_9NO_2$	× 3	=	$C_{15}H_{27}N_3O_6$
Valine	$C_5H_{11}NO_2$	× 1	=	$C_5H_{11}NO_2$
Serine	$C_3H_7NO_3$	× 2	=	$C_6H_{14}N_2O_6$
			+)	
				$C_{98}H_{220}N_{54}O_{38}$
	$17\,H_2O$			H_{34} O_{17}
			−)	
Salmine used				$C_{98}H_{186}N_{54}O_{21}$

Seeing the ratio of the numbers of the atoms of carbon and nitrogen in the analytical results (Table I, II and IVa) of our salmine salts, it could be shown that C/N is almost 1,8; and therefore it may be suggested that the empirical formula of our salmine is $C_{98}H_{186}N_{54}O_{21}$.

It may be confirmed that, as there is no difference between the formula of our salmine and those of the European one, ours is practically the same as that obtained from the European salmon, used by Kossel.

[II] Analytical methods of free aminoacids after partial hydrolysis.

It must be expected that, when the protamine is put under the process of the partial hydrolysis, in the hydrolysate there will be undecomposed protamine, proton, peptide, and aminoacid, and as for the group of the said peptide, those compounds from the dipeptide to those high in degree to next to the proton according to the conditions of hydrolysis, will be found in a mixed up state. For estimating these free arginine and free monoaminoacids, we must first of all remove, from this complex hydrolysate, every other compound.

(1) Removal of undecomposed salmine. We carried out the following experiments. Tannic acid solution was added to the solution of salmine sulphate, partially hydrolysed, and after removing the tannin, the precipitate was filtered off by the addition of lead acetate or mercuric chloride. Although we got arginine salt by flavianic acid after the usual treatment, this flavianate had neither peculiar luster nor proper crystal from under the microscope. We conjectured that it may be owing to the existence of lower peptide.

(2) Removal of other compounds. Kossel(3) reported that he separated di- and monoaminoacids after partial hydrolysis of protamine by the silver-baryt method and isolated arginine from peptide by treating the precipitate of phosphotungstate of diaminoacid with 5% SO_4H_2 and 25% alcohol.

By this method, however, we did not arrive at such results as obtained by Kossel, as our arginine flavianate isolated was quite different in luster and crystal form from the salt prepared from pure arginine carbonate, and moreover the Sakaguchi reaction was given in the filtrate of phosphotungstate. It is evident, therefore, that the part of arginine goes to filtrate without precipitating with phosphotungstic acid, as Joseph Charles(20), and Kernot(21) wrote already about this fact.

In a word, the solubility(22) of arginine phosphotungstate is variable according to the degree of acid in solution. Then we examined the degrees of solubility of arginine phosphotungstate in various pH of solution, and arrived at the results that, in the case of neutral solution of arginine carbonate, the precipitate of arginine is dissolved by diluting with 5–10 times of volume of water.

(3) Estimation of acidity in which arginine phosphotungstate is dissolved. We carried out the following experiments with the solution of pure arginine carbonate prepared from gelatine, and those results are as follows:—

Table IV b.

	Vol. of P.W.S. added	pH of solution after dilution to 100 cc with water	Solution after dilution	Arginine-nitrogen
1, Total arginine-N in solution				34,48%
2, In neutral solution	0,5 cc	2,81	Clear	34,48%
3, In acid solution (given solution 10 cc + 4N · SO_4H_2 5 cc)	0,5 cc	1,03	Clear	34,48%
4, In acid solution (given solution 10 cc + 4N · SO_4H_2 10 cc)	0,5 cc	0,73	Remains cloudy	

We recognized from those results that the arginine phosphotungstate is variable in solubility and it dissolves partially in a strong acid medium, i.e. it is dissolved wholly in pH 0,76–2,81. It may be added that according to Peter(22), it precipitates wholly in the case of pH 3,7–7,0.

(4) Determination of arginine in decomposed mixture of partial hydrolysis. The solution of salmine sulphate was prepared and phosphotungstic acid was added. Then we tested the presence of salmine in the filtrate by the Sakaguchi reaction and that of nitrogen by the Kjeldahl method, but both were negative.

For the presence of peptide, we examined the amounts of amino-nitrogen

prior to and subsequent to its decomposition, by means of the filtrate prepared by the partially hydrolysed mixture treated by phosphotungstic acid.

	$NH_2N\%$
Before decomposition	30,0
After decomposition	30,0

There was no fluctuation of amino-nitrogen in the filtrate.

To determine the amount of free arginine, we treated the filtrate of phosphotungstic acid with silver-baryt method, and calculated the arginine from the difference of the nitrogen contained in the filtrate of phosphotungstic acid mentioned above, and in that of silver-baryt just mentioned.

(5) Determination of monoaminoacids in decomposed mixture of partial hydrolysis. After removing Ag and Ba from the filtrate of silver-baryt, the solution was condensed to syrup, and we fractionated it by the difference of its solubility in ethyl and methyl alcohol; the results were, proline soluble in ethyl alcohol, valine soluble in methyl alcohol, but serine insoluble in both solvent—and found their nitrogen by the Kjeldahl method.

We have gone through several experiments one after another, for this removing purpose, and here the conclusion is summed up. In removing sulphuric acid from the hydrolysate with $Ba(OH)_2$, the melanine and other matters were separated, and when phosphotungstic acid is added to the neutral solution, free arginine and aminoacids remained soluble in the filtrate, while others were precipitated by that acid. From the filtrate, arginine is precipitated by the silver-baryt method, and nitrogen is determined in each stage, then by calculation, arginine and monoaminoacids are determined.

[III] Arginine and monoaminoacids set free by partial hydrolysis.

A given amount* (0,5 gm) of salmine sulphate, together with a given volume (10 cc) of sulphuric acid of definite concentration† (N, 2N and 4N), is heated up to 100°C. in a sealed glass tube, and taken out at given intervals and analysed by the above described method.

---

*) As the protamine is hygroscopic, we could not take the exact amount of sample in each tube, and so we satisfied ourselves in weighing about 0,5 gm for practical purpose.

†) We shall show the results in the cases of 2N and $4N \cdot SO_4H_2$ only.

(The reaction velocity constants are calculated as a monomolecular reaction.)

Table V.

With $2N \cdot SO_4H_2$

	Total	Interval of time (hour)												
		1	2	4	8	10,5	11,5	12,5	16	21	22	23	24	32
	%	%	%	%	%	%	%	%	%	%	%	%	%	%
Total-N		4,40	6,37	7,34	8,01	9,83	10,63	10,95	12,17	12,34	12,99	13,51	13,87	15,77
		4,39	6,37	7,46	8,09	10,01	10,37	10,95	12,13	12,34	12,97	13,51	13,87	16,04
Average	24,44	4,40	6,37	7,40	8,05	9,92	10,50	10,95	12,15	12,34	12,98	13,51	13,87	15,91
Arginine nitrogen	21,80	3,88	5,31	5,36	5,42	7,28	7,86	8,31	9,51	9,70	10,34	10,87	11,23	13,40
Mono-amino-acid-N		0,53	1,06	2,00	2,63									
		0,51	1,06	2,09	2,63									
Average	2,64	0,52	1,06	2,05	2,63									

Table VI.
Total nitrogen.

Total nitrogen in sample = ...24,44%

Interval of time (min.)	N % in sulphate	N % in free protamine	N % in total N	Velocity constant $\times 10^5$
60	4,40	5,64	18,00	329
120	6,37	8,16	26,06	251
240	7,40	9,48	30,28	150
480	8,05	10,31	32,94	83
630	9,92	12,71	40,59	82
690	10,50	13,45	42,96	81
750	10,95	14,07	44,80	79
960	12,15	15,57	49,71	71
1260	12,34	15,81	50,49	56
1320	12,98	16,63	53,11	57
1380	13,51	17,31	55,28	58
1440	13,87	17,77	56,75	58
1920	15,91	20,38	65,10	55

Table VII.
Afginine nitrogen.

Total nitrogen of arginine in sample = ...21,80%

Interval of time (min.)	N % in sulphate	N % in free protamine	N % in total N	Considered total arginine-N as 100	Velocity constant $\times 10^5$
60	3,88	4,84	15,88	17,80	325
120	5,31	6,80	21,73	24,36	233
240	5,36	6,87	21,93	24,59	117
480	5,42	6,94	22,18	24,86	59
630	7,28	9,33	29,79	33,39	64
690	7,86	10,07	32,16	36,06	65
750	8,31	10,65	34,00	38,12	64
960	9,51	12,18	38,91	43,60	60
1260	9,70	12,43	39,69	44,50	47
1320	10,34	13,25	42,31	47,43	49
1380	10,87	13,93	44,48	49,86	50
1440	11,23	14,39	45,95	51,51	50
1920	13,40	17,17	54,83	61,47	50

Table VIII.
Monoaminoacid nitrogen.

Total nitrogen of monoaminoacids in sample = ...2,64%

Interval of time (min.)	N % in sulphate	N % in free protamine	N % in total N	Considered monoamino-acid-N as 100	Velocity constant $\times 10^5$
60	0,52	0,67	2,13	19,70	364
120	1,06	1,36	4,21	40,15	426
240	2,05	2,63	8,39	77,65	624
480	2,63	3,37	10,76	99,62	

Table IX.
With $4N \cdot SO_4H_2$

	Total	Interval of time (hour)			
		1	2	4	8
	%	%	%	%	%
Total nitrogen		5,71	7,70	8,22	9,15
		5,50	7,70	8,23	9,31
Average	24,44	5,61	7,70	8,23	9,23
Arginine nitrogen	21,80	4,54	5,46	5,59	6,59
Monoaminoacid-N		1,09	2,24	2,64	
		1,05	2,24	2,64	
Average	2,64	1,07	2,24	2,64	

Table X.
Total nitrogen.

Total nitrogen in sample = ...24,44%

Interval of time (min.)	N % in sulphate	N % in free protamine	N % in total N	Velocity constant $\times 10^5$
60	5,61	7,19	22,95	433
120	7,70	9,87	31,56	313
240	8,23	10,54	33,67	171
480	9,23	11,83	37,78	99

Table XI.
Arginine nitrogen.

Total nitrogen of arginine in sample = ...21,80%

Interval of time (min.)	N % in sulphate	N % in free protamine	N % in total-N	Considered total arginine-N as 100	Velocity constant $\times 10^5$
60	4,54	5,82	18,58	20,83	389
120	5,46	7,00	22,34	25,05	240
240	5,59	7,16	22,87	25,64	123
480	6,59	8,44	26,96	30,23	75

Table XII.
Monoaminoacid nitrogen.

Total nitrogen of monoaminoacids in sample = ...2,64%

Interval of time (min.)	N % in sulphate	N % in free protamine	N % in total-N	Considered total arginine-N as 100	Velocity constant $\times 15^5$
60	1,07	1,37	4,38	40,53	866
120	2,24	2,87	9,17	84,85	1571
240	2,64	3,38	10,80	100,00	

From the results mentioned above, we can recognize that, in the case of $2N{\cdot}SO_4H_2$, in which he total monoaminoacid sare set free, one fourth of arginine is liberated, and after the elapse of eight hours, the velocity constant of arginine set free becomes almost definite.

On the other hand, comparatively much amount of arginine compounds seems to exist in the precipitate of phosphotungstic acid, that is, those arginine compounds must be higher ones as peptide consisting of arginine only, seeing that, at that time, all monoaminoacids are set free and there is no other unit, but arginine.

[IV] Residue in the partial hydrolysis.

In order to ascertain in what condition a portion of the residua, which does not completely decompose, is placed, we carried out the following experiments.

(1) Residue in eight hour hydrolysis. We have made at first a free

solution of the phosphotungstate prepared by the hydrolysate of eight hour decomposition with $2N.SO_4H_2$, and condensed it to a small volume under diminished pressure, keeping its neutral state. It gave the biuret reaction, but with picric acid and sodium hydroxide, it was negative.

We have determined the total nitrogen of the residue and its amino nitrogen prior to and subsequent to the decomposition. The results obtained are shown in the following figures:—

Table XIII.

Nitrogen	N %			
	Found	Average	Found	Average
Total nitrogen	16,27 % 16,27 %	16,27 %		
Amino nitrogen before decomposition			1,78 % 1,77 %	1,78 %
Amino nitrogen after decomposition			3,86 % 4,28 %	4,07 %
Total nitrogen precipitated with silver-baryt	16,13 % 16,26 %	16,20 %		

From the above table, it may be seen that when salmin sets its total monoaminoacids free in eight hours some compounds to two or more arginines combined each other remain in the precipitate of phosphotungstic acid. Because, the nitrogen precipitated with that acid which is 16,27%, is wholly precipitated after decomposition, with silver-baryt, and moreover one fourth of which is 4,07% of the amino nitrogen increased by decomposition.

There is an interesting problem; How many arginines are in the residue and in what linkage are they? We assume that there is peptide-linkage between the arginines by increasing amino nitrogens twice as much.

If the residue consists in triarginides only, it must be 1,36% NH_2-N before decomposition and in diarginides only, it must be 2,05%. From the number of molecule, there are nine molecules of arginine in the precipitate, three molecules being set free; therefore, we thought, the compounds precipitated with phosphotungstic acid are composed of chiefly three diarginides with a triarginide.

	Calculated NH_2-N
As diarginide	2,05%
As triarginide	1,36%
As mixture of di- and triarginide in same number	1,70%
As mixture of di- (3 mol.) and triarginide (1 mol.)	1,82%

(2) Residua in 10,5 and 23 hour hydrolysis. Again in order to examine the residue after 10,5 hour and 23 hour decomposition when even numbers of arginine molecule—1/3 and 1/2 of total arginine are set free. we have carried out experiment with $2N.SO_4H_2$.

Table XIV.

	After 10, 5 hours						After 23 hours					
	Nitrogen %			Amino-nitrogen %			Nitrogen %			Amino-nitrogen %		
	Found	Average	Calculated	Found	Average	Calculated	Found	Average	Calculated	Found	Average	Calculated
Total-N	14,49 14,75	14,62	14,52				11,13 10,86	10,99	10,90			
NH_2-N before decomposition				1,93 1,76	1,85	1,82				1,47 1,31	1,39	1,36
NH_2-N after decomposition				3,64 3,59	3,62	3,64				2,61 2,77	2,69	2,72
Total-N ppted. with Ag-baryt	14,44 14,44	14,44					10,85 10,85	10,85				

From the table, it may be seen that, percentage of nitrogen in every stage in both cases coincides respectively with that of calculation, that is, NH_2-N becomes twice as much after decomposition. Thus, after 10,5 hours, 1/3 of the total arginine is contained at least in the form of dipeptide in the residue, while, one arginine is in linkage with one of dipeptides, forming one triarginide after eight hours. The unseparated portion of arginine remains in the form of diarginide, and that diarginide gradually sets itself free as arginine.

Moreover, from the velocity constants on the table VI, and VII, in which they are about definite after eight hours and on in both cases of the total nitrogen and of the arginine nitrogen, it must be said that the liberation of arginine from the unseparated portion after eight hour hydrolysis is of monomolecular reaction.

[V] Individual monoaminoacids set free by partial hydrolysis.

In the present experiment, we intended to determine the quantity of individual monoaminoacids liberated at each interval of time. The manuplation is just the same as in the case of $2N.SO_4H_2$ and the results are as follows:—

Table XV.
With $2N \cdot SO_4H_2$

	Interval of time (hour)							
	1	2	3	4	5	6	7	8
Total-N	4,37	6,34	6,67	7,35	7,58	7,65	7,71	8,05
Arginine nitrogen	3,85	5,22	5,24	5,45	5,46	5,48	5,39	5,42
Total mono-aminoacid-N	0,52	1,12	1,43	1,90	2,12	2,17	2,32	2,64
Proline-N	0,24	0,41	0,65	0,92	1,16	1,20		
Valine-N	0,20	0,47						
Serine-N	0,07	0,24	0,52	0,52	0,49	0,49	0,62	0,99

Table XVI.
Monoaminoacid nitrogen.

Total nitrogen of monoaminoacids in sample = ...2,64%

Interval of time (min.)	N % in sulphate	N % in free protamine	N % in total-N	Considered monoamino acid-N as 100	Velocity constant $\times 10^5$
60	0,52	0,67	2,13	19,70	365
120	1,12	1,43	4,58	42,42	410
180	1,43	1,83	5,85	54,17	433
240	1,90	2,43	7,77	71,97	530
300	2,12	2,72	8,68	80,30	541
360	2,17	2,78	8,87	82,19	479
420	2,32	2,97	9,49	87,88	503
480	2,63	3,37	10,76	99,62	

Table XVII.
Proline nitrogen.

Total nitrogen of proline in sample = ...1,20%

Interval of time (min.)	N % in sulphate	N % in protamine	N % in total-N	Considered total mono-aminoacid-N as 100	Considered total proline N as 100	Velocity constant $\times 10^5$
60	0,24	0,31	0,99	9,09	20,00	372
120	0,41	0,53	1,68	15,53	34,17	348
180	0,65	0,83	2,66	24,62	54,17	433
240	0,92	1,18	3,76	34,85	76,67	606
300	1,16	1,49	4,75	43,94	91,67	1131
360	1,24	1,59	5,07	46,97	103,33	

Table XVIII.
Valine nitrogen.

Total nitrogen of valine in sample = ...0,45%

Interval of time (min.)	N % in sulphate	N % in protamine	N % in total-N	Considered total mono-aminoacid-N as 100	Considered total Valine N as 100	Velocity constant $\times 10^5$
60	0,20	0,26	0,82	7,58	44,44	980
120	0,47	0,60	1,92	17,80	104,44	

Table XIX.

Serine nitrogen.

Total nitrogen of serine in sample = ...0,99%

Interval of time (min.)	N % in sulphate	N % in free protamine	N % in total-N	Considered total mono-aminoacid-N as 100	Considered total serine-N as 100	Velocity constant $\times 10^5$
60	0,07	0,09	0,29	2,65	7,07	122
120	0,24	0,31	0,98	9,09	24,24	231
180	0,52	0,67	2,13	19,70	52,53	414
240	0,52	0,67	2,13	19,70	52,53	310
300	0,49	0,63	2,00	18,56	49,49	228
360	0,49	0,63	2,00	18,56	49,49	190
420	0,62	0,79	2,54	23,48	62,63	234
480	0,99	1,27	4,00	37,50	100,00	

It seems to be that the process of hydrolysis went on smoothly as is shown in the tables of the total nitrogen of monoaminoacid and its velocity constant, though there are the small differences of the amount of nitrogen of individual monoaminoacids, to which any method of quantitative analysis is in applicable.

The tables show: after one hour, 1/2 of valine is liberated; after two hours, all of it is separated, together with the liberation of 1/3 of proline; after six hours, the rest proline is set free, while 1/2 of serine after three hours and the rest after eight hours are separated. In short, among these three monoaminoacids, valine is set free at first and then proline, and serine remains to the end.

For valine is a common α-monoaminoacid and the formula of proline is in a ring form without amino group, but serine is an oxy-α-aminoacid, and considering its resistance toward the hydrolytic agent, it must be thought that the serine can not be in only Fischer's peptide but in Bergmann's ester peptide having arginine linkage with hydroxyl group of serine as well.

Peptide Ester peptide

SUMMARY.

In the present experiment, we ascertained the following facts:—

(1) Salmine sulphate from Japanese salmon is the same as Kossel's, in its properties, its elementary composition, and in the variety and the amount of the aminoacids.

(2) Arginine phosphotungstate is quite soluble in the aqueous solution, pH of which is about 0,76–2,81.

(3) When the salmine is placed under the partial hydrolysis (2N and $4N.SO_4H_2$), all of monoaminoacids are liberated after eight and four hours respectively.

(4) After eight hours, in case of $2N.SO_4H_2$, there remain insoluble compounds of arginine only as phosphotungstate, and they are a mixture of diarginide with a triarginide.

(5) When there are even number of arginine molecule remained as insoluble salt, that is, after 10,5 and 23 hours, the unseparated portion of arginine remains in the form of diarginide, and liberates itself gradually as arginine, during the elapse of each interval.

(6) Towards the hydrolytic agent (SO_4H_2), the resistance of valine is weaker than that of proline, and that of serine is the strongest among them.

In conclusion, we express our thanks to Keimeikwai for their contributing towards the expenses of our experiment.

June Showa 8 (1933) Chemical laboratory, Imp. Fisher. Institute, Tokio.

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Concretions and Pseudo-concretions dredged from the Sea bottom around Japan.

(Sôyô-maru expedition)

Hirosi Niino.

(Received April 20, 1934)

Many bottom samples including pebbles and concretions[9] were collected by the surveying ship Sôyô-maru of the Imperial Fisheries Experimental Station from the continental shelves around the Japanese Islands. Among the pebbles derived from soft but compact rocks such as shale, fine sandstone, and tuff, I found some pebbles which look like concretions in appearance and structure. Those pebbles which show a characteristic concentric structure owing to a process, not concretionary, are called here by the name of "*Pseudo-concretions.*"

Table I. The stations where the samples were dredged.

Station number	N. Latitude	E. Longitude	Depth in meters	Bottom water temp. °C	Bottom water Sp. Gr. S_4^{15}	Bottom character
273	34° 45′ 45″	138° 30′ 05″	123	13,2	25,54	S. M.
278	34° 42′ 50″	138° 30′ 30″	79	14,8	25,50	Cy. G. M.
284	34° 38′ 30″	138° 27′ 30″	71	10,0	25,64	G. P.
325	32° 45′ 00″	132° 23′ 30″	210	15,2	25,65	M. P.
563	39° 08′ 45″	134° 20′ 00″	340	1,0	25,28	M. P.
565	39° 20′ 00″	134° 04′ 00″	462	0,5	25,26	S. M.
610	38° 51′ 33″	139° 02′ 50″	142	11,9	25,47	R
617	38° 59′ 50″	139° 38′ 07″	106	3,1	25,58	R. Sh.
off Kominato	—	—	188	—	—	G. S.

M....Mud, Cy....Clay, S....Sand, P....Pebble, G....Gravel, S....Shell, R....Rock.

I. Pseudo-concretions.

a) A pebble dredged from the station No. 284. (Pl. XIII, Figs. 1, 2, 3)

The pebble in question is made of tuffaceous sandy shale. It is depressed ellipsoid in shape, 14.6 cm. in the longer diameter and 4.3 cm. in the shorter. The surface is yellowish brown in colour, smooth and not

striated, but with some holes made by boring molluscs. Organisms are rarely found on its surface except some corals or calcareous algae. On examining a cross section of the pebble, there is found a thin black-brown layer forming the crust, within which, parallel to the surface, a light yellow zone with a thickness of 7 mm. is developed. On close examination, the light yellow zone is seen to be composed of several coloured layers, inside of which there is a chocolate coloured zone, about 6 mm. wide, which is composed of several light coloured concentric stripes. Surrounded by the chocolate coloured zone, there is a homogeneous gray core. All the coloured zons except the core consist of limonite grains cemented by dark brown clayey materials, the shades of the colour being due to the amounts of limonite concentrated. Those layers or rings are arranged parallel to the surface of the gravel just as "line of growth"[5,8] of a concretion.

Under the mineralogical microscope, quartz, feldspar, augite, and tests of foraminifera are arranged in a definite direction. It shows the original structure corresponding to the bedding of the mother rock of the pebble, while the concentric coloured layers run across the direction of the original structure. This fact suggests that the sea water diffused through the pebble and precipitated mineral matters without relation to the original structure. Thus, precipitation took place periodically, making concentric stripes Parallel to the surface of the pebble; this is the "Liesegang's phenomenon."[2,3] As it is seen in some parts of the thin section, there are microscopic networks formed by the secondary precipitation of limonite in primary shrinkagecracks, the concentric coloured rings being developed across or sometimes incloseing the networks. (Pl. XIII, Fig. 3.) Hardness is variable in each concentric layer, so that when struck with a hammer, the pebble is easily broken into layers as in an onion-bulb.

Crystals of aragonite and calcite are abundantly contained in the external light coloured zone as well as in the central core, so that if a slice of the pebble is put into dilute hydrochloric acid, the light coloured part is easily dissolved and the dark portions remain as concentric ridges. When a slice of the pebble is put in the solution of Na_2S, the greater parts of the coloured layers are changed into black owing to the precipitation of iron sulphide.

Thus, although the pebble under consideration looks like a concretion by the presence of secondary concentric rings of minerals, the rings have no relation to the original structure of the pebble; hence I call it "*pseudo-concretion.*"

b) A gravel of shale dredged from the station No. 325. (Pl. XIV, Fig. 3)

Along the external border of the cross section of the gravel, there is a narrow dark zone (Pl. XIV, Fig. 3. A), inside of which follow a narrow light coloured zone and a broad dark zone, succeeded by the core which is variegated in colour. The same phenomena as observed in the preceding sample take place when a slice of this gravel is put into the solution of HCl or Na_2S.

c) A gravel dredged from a depth of 188 m. at the mouth of the Kominato Bay. (Pl. XIV, Fig. 4)

This is a gravel of tuffaceous sandstone, with a diameter of 10 cm., complately water worn, showing a dark brown colour owing to deposition of ferruginous matter on the surface. On polishing the surface of the section of this gravel, some coloured edges of bedding planes make their appearance, the origin of this colouration being evidently different from that of the outer brown layer.

d) Pebbles obtained from the stations No. 563 and No. 565. (Pl. XIV, Figs. 1, 2)

A pebble of liparitic tuff was obtained from the station No. 563 (Pl. XIV, Fig. 1). A green layer with a width of 1 mm. is developed around the surface of the pebble, the inner portion being light yellow in colour. Under the mineralogical microscope, along the inner boundary of the green layer, there is a zone in which a row of black patches consisting of pyrite grains is developed.

A gravel obtained from the station No. 565 (Pl. XIV, Fig. 2) is of greywacke sandstone. Under the microscope, there is seen, near the surface of the gravel, a band of light brown colour, along the inner boundary of which black spots of pyrite are developed, arranged concentrically to the surface.

It seems that in the pebbles or gravels of compact sedimentary rocks which sank to the bottom, there occurred a secondary structure under certain conditions, by precipitation of mineral matters from the sea water percolating and diffusing through them, as in case of the weathering[1,5] rings formed within the outer layer of rocks exposed to the air.

II. Concretions.

A. A concretion obtained from the station No. 273 (Pl. XVI, Figs. 3, 4) looks like a pebble of coarse sandstone which has an ellipsoidal shape, with the longer diameter of 5 cm. and the shorter of 3 cm. It is hard and gray in colour. As can be seen on its section, the external layer, which is 3 mm.

wide, consists of a secondary mantle of compact sandstone and the core of light brown, sandy claystone.

Under the microscope, the external secondary mantle consists of quartz, feldspar, biotite and calcite cemented by clayey material. There is a clear demarcation between the outer and the inner parts, differing in colour and structure. In the claystone which forms the inner part, there is a distinct brown zone near its outer boundary. This zone is distinguished in colour from the inner portion but exactly the same in structure and components. The difference of the colour between the two parts are due to difference of concentration of limonite. The outer mantle of the concretion was made by concretionary adhesion of sand on the outside of the brown claystone pebble.

B. Concretion obtained from teh stations No. 278 (Pl. XV, Figs. 1, 2, 3) and No. 584.

The concretion obtained from the station No. 278 is of soft loose claystone. Under the microscope, it shows some fine concentric layers, which are composed of ferruginous materials of secondary precipitation. Quartz and other minerals are concentrically arranged parallel to the coloured layers. A question remains, whether the precipitation of coloured rings was involved in the same process as the growth of the concretion or originated from diffusion of solutions after the concretion had been fully made up. But from the fact that minerals composing the concretion are arranged in the same direction as the coloured layers, it is evident that the mode of formation of the concretion in question is somewhat different from that of the pseudo-concretion in which there is no concordanec between the arrangements of constituent minerals and coloured bands.

The concretion got from the station No. 584 resembles closely that from the station No. 278 in its colour and appearance. On putting the concretion in dilute hydrochloric acid, the central core which has a light colour is soon dissolved on bubbling, while the dark outer layer is not. When struck with a hammer, the concretion is easily broken into pieces of coloured layers.

C. Concretion got from the stations No. 610 (Pl. XVI, Figs. 1, 2) and No. 617.

The concretion got from the station No. 610 has a spindle shape, about 20 cm. long and 7 cm. across. The outer layer of the concretion is composed of compact claystone of reddish-brown colour, 7 mm. thick, while the interior, of homogeneous fine sandstone. The outer layer is easily peeled off into scale-like pieces on striking with a hammer. There is a dark-brown ring

developed around the core sandstone. This concretion was formed at the sea bottom by coating of clay around a gravel of fine sandstone. The concretion got from the station No. 617 is the same as that from the station No. 610 in appearance and structure. It has the shape of an egg cut transversely, 8 cm. in length and 5 cm. in diameter.

Résumé.

1. Many kinds of concretions were dredged from the sea bottom around the Japanese Islands. Among them those formed by apposition of materials on external side show concentric rings, some of which were formed by periodic precipitations of minerals after the concretions had been fully grown.

2. Among gravels of compact shale, sandstone, or tuff dredged from the sea bottom, there are some which show coloured rings formed by periodic precipitations of minerals from the diffusing solutions. Those rings are concentrically arranged, indifferent to the original structure of the gravels. Such gravels are often mistaken for true concretions.

In conclusion I wish to express my sincere thanks to Dr. K. Okamura for his kind guidance and also to Prof. Dr. T. Kato for his kind help and criticism. I am also grateful to Mr. H. Marukawa who placed the collection at my disposal.

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The Desmid-flora of the Northern Kurile Islands.

Yoshikazu Okada

(With 15 Plates, 10 Text-figures and 1 Map.)

(Received Jun. 21, 1934)

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1. Introduction.
2. General View of the Northern Kuriles.
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1. Introduction.

In Japan, the Desmid-flora is known in comparatively few places even at the present age. This is especially true of the Desmid-flora of the central districts, and the northern parts of Japan; although Junsai-numa in Hokkaidō was surveyed a little by both Messrs. Roy and Bisset, forty-eight years ago, but, those of the Kurile Islands as well as Saghalien, are, of course, entirely unknown.

Hence, I have begun to inspect the conditions of the geographical distribution of the Desmid in these northern regions. For the preparation of this inspection, in 1924, I went over to Ō-numa and Junsai-numa, mentioned above; and, to the interior parts of Hokkaidō, and also to the Rishiri and Rebun Islands, in the years of 1925 and 1926; and again in 1927, to Saghalien and Hokkaidō, for the purpose of collecting the materials for a survey of Desmid; and also, in 1929 I spent about a month in the Southern Kurile Island for this purpose. Added to this, I wish to mention here that in 1930 and 1932 I was fortunate enough to get some important materials of the Kamchatka peninsula from Mr. S. Takayama; and, moreover, I got materials from the

Aleutian Islands, collected by Mr. Y. Kobayashi in 1931. Thus I was able to make a comparative study of the Desmids in these northern districts.

During the summer season of 1931, with three of my friends, I made an extensive collection journey over almost every island of the Northern Kuriles, the most important and yet entirely unknown districts for Desmid hetherto; because of the inconvenience of communication, and I took every opportunity of collecting materials during our stay there of forty-three days.

The results of this research which I want to present to you now, therefore, are really based upon the materials mentioned above; and I am going to try to make clear the characteristics of the Desmid-flora in the northernmost as well as the eastern extrimites of Japan.

In making this investigation, I owe much to the late Prof. Dr. Yoshisada Yabe, Prof. Dr. Yaichiro Okada, and Dr. Makoto Nishimura; and I must also express my sincere gratitude to the late Hikoichi Motoyama, the former President of the Ōsaka Mainichi and the Tokyo Nichi-Nichi, who was kind enough to give me his cordial support.

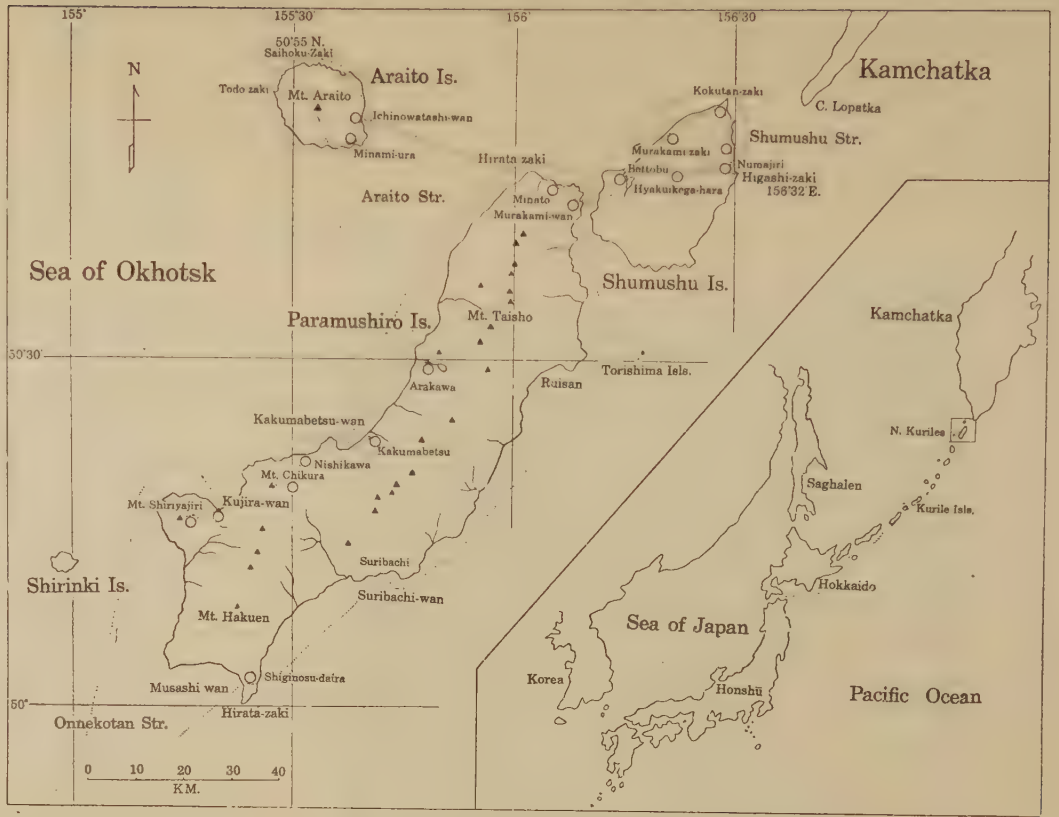
I also wish to express my hearty thanks to Prof. Saburo Ueda, Prof. Dr. Kintaro Okamura and Prof. Dr. A. Terao who kindly gave me very helpful suggestions and criticisms in regard to the present paper.

2. General View of the Northern Kuriles.

Geographical Situations: The Northern Kurile Islands, viewed from the biological standpoint, consist of four islands; namely, Araito (*or* Alaid), Shumushu (*or* Shimushu), Paramushiro (*or* Paramushiru) and Shirinki, all of which are situated in the northern part of the Kurile Islands. These islands extend as far as from Paramushiro Island, 50° N., to Araito Island, 50° 55′ N.; from the eastern end of Shumushu Island, 156° 32′ E. to the western end of Paramushiro Island, 155° 12′ E. Thus, these islands form boundaries of Japan in the north, as well as in the east; and are lying about 21 miles off Cape Lopatka in the extreme south of Kamchatka.

Araito Island, to the extreme north of the four, is nearly round in its shape; its length being 16 kilometers, and its width 14 kilometers.

THE ISLANDS OF NORTHERN KURILES



The dotted lines indicate the route taken by the author, and "○" are used to show the stations where the materials were collected.

On this Island is situated Mt. Araito (2339 meters high), one of the highest mountains of the Kuriles as well as of Hokkaidō. The foot of the mountain is very steep, and extends quite to the seashore. The mountain is rather a new extinct volcano, and forms a typical fine conide. The whole field, from the foot half way up the mountain, is covered with *Alnus maximowiczii* Call; and the grass fields around them abuts on the sea by the cliff. Up to the region of *Alnus* there stretches a vast field covered with grasses adorned by various kinds of beatiful alpine flowers; and then from there to the top, the mountain is covered with 'lapilli'; but not a single tree to be seen.

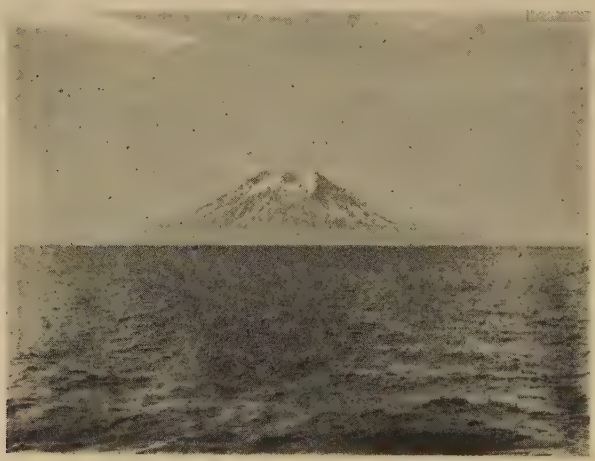


Fig. 1. Araito Is. (viewed from tho south-west) July 9, 1931.

The rivers of the island flowing from that mountain are generally shallow, and the water not transparent; the river beds are composed of sand and lava pebbles. So there are only a few rivers, and these flow in the thawing season only; and it is no exaggeration to say that there are rivers that have no water at all. The conditions of the island being such, it is only natural that there are only a few morasses or lakes all over the islands.

The neighbouring Shumushu island is 40 kilometers long and 27 wide; and, in spite of the fact that it is only 50 kilometers away from the Island of Araito to the eastern direction, is quite different in appearance—the whole island being composed of the gently sloping grassy hills, adorned by *Pinus pumilla* Regel dotted here and there; and even the highest portion of it is only 189 meters.

The island abounds in rivulets, lakes, and morasses; and above all, in the interior part there are not a few swamps, such as Hyakuike-gahara, Misonōgahara, Miyoshino; and ponds, such as Bettobu-numa, Kaihyō-numa etc.

Paramushiro Island, the shape of which is long and narrow from

the north-east to the south-west, is one of the largest of the above mentioned four, being about 125 kilometers in length, and 36 in width; and across the Paramushiro Channel, within a distance of less than a mile to the south-west of Shumushu Island, is entirely different in its external appearance from the before mentioned islands. This Island consists of many high, noble peaks, running from the north-east to the south-west end; such as Mt. Chikura (the highest peak in the island, 1815 m.), Mt. Kanmuri (1680 m.), Mt. Dai-iwozan (1493 m.), Mt. Nekoyama (1471 m.) etc. and on which we saw, even in August, the remaining snow piled very high.

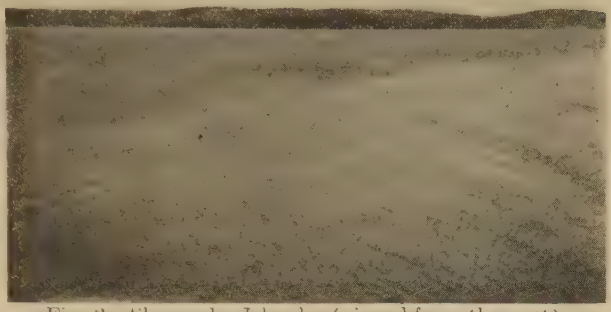


Fig. 2. Shumushu Island. (viewed from the west) July 10, 1931.

On this island, here and there are scattered many lakes, morasses and marshes and also many rivers are seen among them.

Climate: We have no reliable data concerning the climate of the Northern Kurile Islands in general; we know only that they differ from each other.

For instance, in 1926 at the Island of Araito the highest temperature recorded in July was 66°F.; while the lowest was 41°F.; and, in August 72°F. and 50°F. The atmospheric pressure

Fig. 3. Northern part of Paramushiro Island. (western coast) July 9, 1931.

of the island also in July stood at 763 m.m. at its highest; and, at the lowest at 745 m.m. and in August, the highest was 762 m.m. and the lowest 747.5 m.m.; and it is said that it snowed for the first time on the 15th of August of the same year. The remaining snow was still to be seen here and there, especially on the mountain of Araito, or on those of Paramushiro; and even on the plains and the seashore on the eastern side of Shumushu, snow sometimes remains all the year round.

Such being the condition, we seldom have fine, calm weather; but mostly foggy, melancholy weather; especially from July to September.

Inhabitants: Though the inhabitants of the Northern Kuriles at present are mostly Japanese, formerly there were natives of Aleut and Kamtchadale, also Russians; and the Ainus were found until they emigrated to the Island of Shikotan in the 17th year of Meiji. So even to-day there can be seen many characteristics of the previously existing races. The inhabitants of the island are all engaged in fishing. They cross the sea in April and return home in September, leaving only a few of them to reside on the island. The inhabitants numbered 1,000 in the year of 1931, distributed among forty fishing stations along the seacoast; and, they were engaged in fishing codfish, trout, and crab.

Communications: To travel over these districts is very hard at present, of course, as regular liners sail only once a month even in the fishing season; and communication between these islands is maintained only by a few ships which do not sail frequently as I have just stated.

From November till April these islands are almost ice-bound, so that navigation during this time is absolutely impossible.

Roads have never been constructed; and neither inn nor shop can be found in these districts.

Added to the inconvenience of poor means of communication, we ourselves, had quite a fearful time, for wild beasts, such as bears, abound there.

3. Materials and Places for Collection

The materials for my research were chiefly collected in the three islands: namely, Araito, Shumushu and Paramushiro. We spent forty-

three days in these northern islands, and chose seventeen places for our collecting stations as already indicated on the map.

The materials tubed, numbering about one hundred, were preserved in 10% formalin, out of which I selected about sixty for the study of the Desmid.

The following is a general description of the places in which we were engaged in collecting the materials.

(A) Araito Island

As this island is really just the volcanic mountain of Araito itself; lakes, and swamps are scarce. As for the rivers, they contain water only during the snow thawing season, as I have mentioned before; and, on account of this, there exists only a few places for collecting the necessary materials of our researches, and so we got only a few specimens along the little rivulets near Minami-ura, and so I found the places not very desirable for the study of Desmid.

The materials collected in the island were from the vicinity of Ichinowatashi-wan and that of Minamiura; the former was rich in *Vaucheria*, and the latter in Diatoms; and Desmids were scarcely seen among them.

The chief Desmids found are as follows:

Euastruma Didelta (Turp.) Ralfs
Euastrum bidentatum Näg.
Staurastrum pilosum (Näg.) Arch. etc.

(B) Shumushu Island

The reason why this island abounds in the places favourable for collectiong Desmids is that there are many streams, lakes and swamps.

Above all, in the heart of the island and, to the north we found innumerable lakes, morasses, and swamps, large and small, all favorable to our study.

The Desmid gathering places in the island were six in number, and out of these I found two places most suitable; one is in the central districts of Hyakuike-gahara, and the other is in the vicinity of the cape of Kokutan. The lakes and morasses dotted in the former districts are generally shallow, and many kinds of Cyperaceae and

Fig. 4. Bettobu-numa, Shumushu Island. Aug. 15, 1931.

Gramineae may be found, accompanied by small shrubs and grasses such as *Andromeda polifolia* L. var. *grandiflora* Lodd., *Geum pentapetalum* Makino, *Betula glandulosa* Michx, *Drosera rotundifolia* L., *Primula cuneifolia* Ledeb. var. *typica* Makino around them. We also found *Hydrurus foetidus* (Vill.) Kirchn. in the flowing water, while in the comparatively deep swamps near Numajiri river, there can be seen *Batrachosperumum Virgum* (Roth.) Ag. var. *keratophytum* (Bory) Sirod. growing.

Some of the interesting species found concerning Desmid in those districts are as follows:

Mesotaenium Kramstai Lemm.
Penium minutum (Ralfs) Cleve var. *crassum* West
Euastrum aboense Elfu.
Euastrum pectinatum Bréb. var. *brachylobum* Wittr.
Euastrum verrucosum Ehrenb. var. *reductum* Nordst.
Micrasterias denticulata Bréb. var. *angustosinuata* Gay.
Xanthidium antilopaeum (Bréb.) Kutz. var. *triquetrum* Lund.
Xanthidium cristatum Bréb. var. *leiodermum* (Roy & Biss.) Turner
Arthrodesmus Incus (Bréb.) Hass. f. *perforata* Schmidle
Staurastrum subpygmaeum West var. *subangulatum* W & G. S. West
Staurastrum tumidum Bréb.

Another interesting phenomenon is that *Cosmarium cylicum* (Bréb.) Kütz. var. *triquetrum* Lund., which is the species of the polar region, was also found in the districts.

The next suitable gathering place is the vicinity of the cape of Kakutan damp zone which has so many small lakes and morasses.

There many kinds of water plants can be gathered: for instance,

Menyanthes trifoliata L., *Utricularia japonica* Makino, *Rotala Hippuris* Makino, and so on.

The Desmids and Diatoms collected here were rich in quantity as well as in quality, and not a few rare species were found.

The following are, I think, worth mentioning:

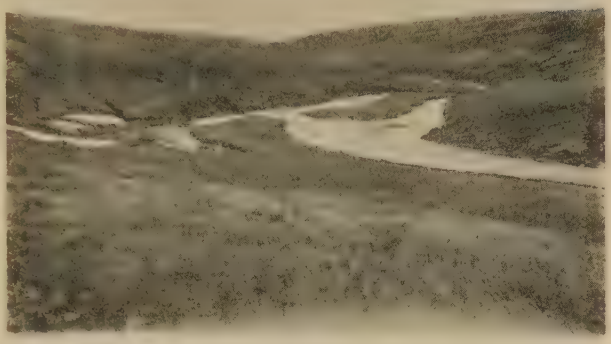


Fig. 5. Streams in the interior part of Shumushu Island. Aug. 18, 1931.

Closterium intermedium Ralfs var. *hibernicum* West
Pleurotaenium Trabecula (Ehrenb.) Näg. var. *rectissimum* W. & G. S. West
Cosmarium formosulum Hoff. var. *Nathorstii* (Boldt) W. & G. S. West
Arthrodesmus Incus (Bréb.) Hass. var. *indentatus* W. & G. S. West

(C) Paramushiro Island

The Island of Paramushiro has so many steep mountains, rivers, plains, lakes and swamps that it forms a favourable place for the collection of the freshwater-algae. During my stay there, I visited nine places for collection. Besides these there were several other places which seem to be good for a study of this kind chiefly in the central highland and on the eastern coast, but, I am sorry to say, I had not time enough to visit these places.

In the northern districts we went over the vicinity of Murakami-wan and Minato fishing-station, where many lakes, and ponds are found.

But, as almost all of them are shallow and transparent, they are not so suitable for the collection of the freshwater-algae; but I found that the damp zone in the neighbourhood of the Iai River, near Murakami-wan was rather an interesting place for the freshwater-algae. It was here that I unexpectedly came across a kind of *Volvox*, and several interesting Desmids. The districts of the Minato fishing-station also are not good for Desmids gathering, and I found only many *Hydrurus* along the streams.

Fig. 6. Lake Chienuma, near Nishikawa fishing-station, Paramushiro Island. Aug. 1, 1931

The chief gathering places for the freshwater-algae on the western part of the island were, nearby in the neighbourhood of the rivers Arakawa, Kakumabetsu, and Nishikawa; but in these districts the Desmid is not found to a great extent. To the southwest of the River Nishi, and in the vicinity of the eastern foot of Mt. Chikura, there extends a vast marsh, and in it are many swamps; yet the Desmids were very few, in spite of the fact that these places were rich in Diatoms as *Cocconeis*, *Pinnuralia* and *Surirella*, mingling with *Coelastrum proboscideum* Bohlin and *Spirogyra* spp. etc.

Fig. 7. Vicinity of Kujira-wan fishining station, Paramushiro Island. Aug. 5, 1931.

In the vicinity of the fishig station of Kujira-wan and also at the eastern foot of Mt. Shiriyajiri, there are many swamps, consisting of many nameless lakes and marshes, which produce along their coast much sphagnums and *Drosera rotundifolia* L., *Pedicularis euphrasioides* Steph., *Menyanthes trifoliata* L., *Sparganium affine* Schnizl., *Rotala Hippuris* Mak., *Isoetes echinospora* Durieu., *Lysichiton camtschatense* Scott., *Potamogeton Franchetii* A. Benn. et Baag. These districts were, therefore, ideal

places for the collection of Desmids. I was able to find many kinds of Desmids, and should like to write of those that will be of most interest to you. They are:

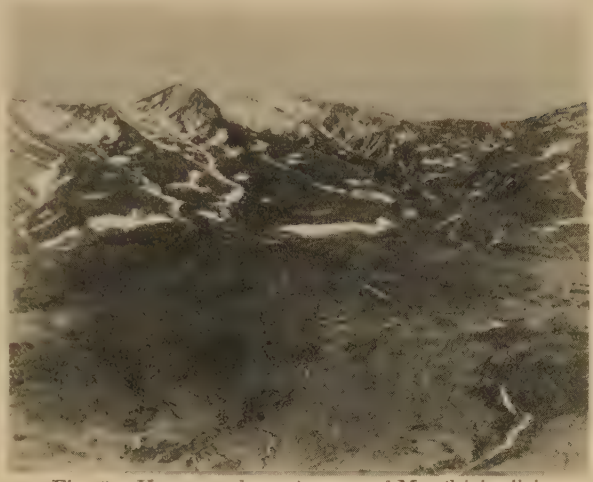


Fig. 8. Vast marsh at the root of Mt. Shiriyajiri, Paramushiro Island. Aug. 4, 1931.

Tetmemorus granulatus (Bréb.) Ralfs var. *attenuatus* West
Euastrum elegans (Bréb.) Kütz. var. *pseudelegans* (Turn.) W. & G. S. West
Xanthidium armatum (Bréb.) Rabenh. var. *fissum* Nordst.
Arthrodesmus Bulnheimii Racib.

Last of all, on the southern side, I went over to the districts of Shiginosu-daira and the vicinity of Kujira-wan.

In the vicinity of Shiginosudaira, meaning "the plain of the snipe's nests" which are found in abundance in the breeding season, there are scatterd innumerable swamps, large and small, marshes, and damp-zones in which *Comarum palustre* L., *Oxycoccus microcarpus* Turcz., *Menyanthes trifoliata* L., *Drssera rotundifolia* L., *Utricularia japinica* Mak., *Rotala Hippuris* Mak. can be seen. There are some which produce in their deeps *Isoëtes echinospora* Durieu. as well as porifera. We can also find a great quantity of Desmids, and there

Fig. 9. Swamps in Shiginosu-daira, Paramushiro Island. Aug. 23, 1931.

Fig. 10. One of the lakes in Shiginosu-daira, Paramushiro Island. Aug. 23, 1931.

are not a few that have never been discovered in our country before. For this reason these districts may be the best places in Paramishiro Island for Desmid collection.

The following are the interesting kinds of Desmids gathered there:

Closterium gracile Bréb. var. *elongatum* W. & G. S. West
Closterium Lunula Ehrenb. var. *biconvexum* Schmidle
Pleurotaenium coronatum (Bréb.) Rabenh. var. *fluctuatum* West
Euastrum verrucosum Ehrenb. var. *rhomboideum* Lund.
Xanthidium antilopaeum (Bréb.) Kütz. var. *polymazum* Nordst.
Staurastrum Johnsonii W. & G. S. West
Staurastrum Ophiura Lund. var. *cambricum* W. & G. S. West
Staurastrum subgrande Borge var. *minor* Smith.

I chose also Mt. Shiriyajiri (1772 m.) to see what mountaneous species might be found there.

About 200 to 300 meters up the mountain there stretches a vast marsh, and there we saw swamps beautifully adorned with *Eriophorum angustifolium* Roth., *Pedicularis euphrasioides* Steph. etc.

I found these districts favourable to Desmids gathering; and, moreover, rich in their species. It was really in these places that I found for the first time, *Cosmarium nasutum* Nordst. forma *granulata* Nordst. known as mountain Desmid.

4. Characteristics of the Flora

My research work at this time was chiefly carried on with the view of studing the materials collected from various places during my comparatively extensive journey to the three islands of the Northern Kuriles; and I know, of course, that there may be many points left upon which I have not touched, as I was obliged to make my trip as short

as possible. But I believe that, in spite of this fact, the investigations of this time will be of some help to scientists who wish to understand the general idea of the Desmidflora of the above mentioned districts in the summer season.

The species of Desmids in the Northern Kurile Islands were, according to my research, 20 genera, 103 species, 43 varieties and 6 forms.

And, these 152 Desmids belong themselves to each genus as follows:

Genera	*Sp.*	*var.*	*form.*	*Total*
Gonatozygon	1	—	—	1
Genicularia	1	—	—	1
Spirotænia	1	—	—	1
Mesotænium	1	—	—	1
Netrium	3	—	—	3
Penium	5	1	—	6
Closterium	11	4	—	15
Pleurotænium	2	2	—	4
Tetmemorus	2	2	—	4
Euastrum	13	5	—	18
Micrasterias	8	3	1	12
Cosmarium	17	9	2	28
Xanthidium	3	5	—	8
Arthrodesmus	3	1	2	6
Staurastrum	24	7	1	32
Sphaerozosma	1	1	—	2
Spondylosium	1	—	—	1
Hyalotheca	3	1	—	4
Desmidium	3	1	—	4
Gymnozyga	—	1	—	1
Total 20	103	43	6	152

Among these the following two species, and one variety, and one form were found to be new to science:

Staurastrum Kurilense sp. nov.
Xanthidium triangulare sp. nov.
Micrasterias denticulata Bréb. var. *notata* Nordst. f. *minor* form. nov.
Arthrodesmus quiriferus W. & G. S. West var. *brevispinis* var. nov.

Besides these, 59 species, 40 varieties, and 4 forms are new to Japan; of these 23 species, 32 varieties and 2 forms are new to Asia as well. They lead us to the conclusion that about two fifths of them are new from Asia and about two thirdths of them are new discoveries in Japan. Thus only 45 Desmids out of 152, are said to be already known.

	Sp.	*var.*	*form.*	*Total*
New to Japan	36	8	2	46
New to Asia	23	32	2	57
New to Science	2	1	1	4
Total	61	41	5	107

So that, these 107 species can be newly added to the list of Desmids of Japan.

Here we perceived such Desmids as have been reported from only a few quaters in the world.

Genicularia elegans W. & G. S. West
Mesotaenium Kramstai Lemm.
Closterium gracile Bréb. var. *elongatum* W. & G. S. West
Closterium intermedium Ralfs var. *hibernicum* West
Closterium Lunula Ehrenb. var. *biconvexum* Schmidle
Pleurotaenium coronatum (Bréb.) Rabenh. var. *fluctuatum* West
Pleurotaenium Trabecula (Ehrenb.) Näg. var. *rectissimum* W. & G. S. West
Euastrum aboense Elfv.
Euastrum elegans (Bréb.) Kütz. var. *pseudelegans* (Turn.) W. & G. S. West
Euastrum pectinatum Bréb. var. *brachylobum* Wittr.
Euastrum verrucosum Ehrenb. var. *rhomboideum* Lund.
Micrasterias denticulata Bréb. var. *angustosnuata* Gay.
Cosmarium formosulum Hoff. var. *Nathorstii* (Boldt) W. & G. S. West
Cosmarium Hammeri Reinsch var. *protuberans* W. & G. S. West
Cosmarium turpinii Bréb. var. *podolicum* Gutw.
Xanthidium antilapaeum (Bréb.) Kütz. var. *polymazum* Nordst.
Xanthidium armatum (Bréb.) Rabenh. var. *fissum* Nordst.
Xanthidium cristatum Bréb. var. *leiodermum* (Roy & Biss.) Turner
Arthrodesmus Bulnheimii Racib.
Arthrodesmus Incus (Bréb.) Hass. var. *indentatus* W. & G. S. West
Arthrodesmus Incus (Bréa.) Hass. f. *perforata* Schmidle
Staurastrum Johnsonii W. & G. S. West
Stausastsum Ophiura Lund. var. *cambricum* W. & G. S. West
Staurastrum subavicula W. & G. S. West
Staurastrum subgrande Borge var. *minor* Smith
Staurastrum subpygmaeum West var. *subangulatum* W. & G. S. West

Hyalotheca Indica Turn.
Desmidium Baileyi (Ralfs) Nordst
Desmidium coarctatum Nordst. var. *cambricum* West

It is indeed an interesting fact that the Desmids in the Northern Kurile Islands have two peculiar qualities which are seen in those of the polar regions; and those of the Alps, or of the Caucasus.

Clasterium Lunula Ehrenb. var. *biconvexum* Schmidle
Cosmarium cyclicum Lund. var. *arcticum* Nordst.
Cosmarium nasutum f. *granulata* Nordst.

In short, I believe that the study of the Desmids of these regions — the northern and the eastern extrimities of Japan—is very important; first, in regard to the peculiarities of distribution; second, because here are found many rare and interesting species; and also many species which have never been reported from Asia, as well as this country, before.

5. Enumeration of the Desmids in the Northern Kuriles

I. Saccodermae

Gen. Gonatozygon De Bary, 1856.

Gonatozygon monotaenium De Bary.

(Pl. 17, fig. 1)

G. monotaenium De Bary. Nordst. 1873, p. 50; Nordst. 1888, p. 186; Borge, 1903, p. 120; W. & G. S. West, 1904, p. 30, pl. 1, figs. 1–7, pl. 5, f. 5; Borge, 1909, p. 12; G. S. West, 1907, p. 107; Strom, 1921a, p. 8; Strom, 1921b, 14; Borge, 1921, p. 13; Allorge, 1924, p. 463; Smith, 1924, p. 5, pl. 52, f. 1; Borge, 1925, p. 14: Donat, 1926, p. 4; Strom, 1926, p. 180; Borge, 1928, p. 98; Homfeld, 1926, p. 13, t. 1, f. 1; Borge, 1930, p. 25; Allorge, 1931, p. 343; Okada, 1932, p. 43, pl. 2, f. 17.

G. Ralfsii De Bary. De Bary, 1858, p. 76, t. 4, figs. 23–25; Cooke, 1886, p. 2, t, 1, f. 1.

G. asperum Rabenh. Wolle, 1884, p. 22, t, 1. f. 1.

Length 230μ, breadth 10μ, breadth of apices 11–12μ.

Dist.—Japan, India, Ceylon, Siam, Sumatra, Greenland, United States, W. Indies, Brazil, Faeroes, England, Wales, Scotland, Ireland,

France, Germany, Austria, Hungary, Spain, Sweden, Norway, N. Russia, W., E. & C. Africa.

Gen. **Genicularia** De Bary, 1858.

Genicularia elegans W. & G. S. West.

(Pl. 17, fig. 14)

G. elegans W. & G. S. West. W. & G. S. West, 1903, p. 539, t. 14, figs. 1, 2; W. & G. S. West, 1904, p. 36, pl. 5, figs. 1, 2.

Length 366μ, breadth 18μ, breadth of apices 20μ.

Dist.—Scotland.

New to Asia.

Gen. **Spirotaenia** Bréb. 1848.

Spirotaenia condensata Bréb.

(Pl. 17, fig. 2)

Sp. condensata Bréb. Ralfs, 1848, p. 179, t. 34, f. 1; De Bary, 1858, p. 75, t. 5, f. 12; De-Notaris, 1867, p. 71; Nordst. 1873, p. 47; Wolle, 1884, p. 33, t. 3, figs. 21, 22; Lagerh. 1885, p. 254; Cooke, 1886, p. 50, t. 19, f. 3; Nordst. 1888, p. 186; Himerl, 1891, p. 589; W. West, 1892, p. 133; Nordst. 1896, p. 78; W. & G. S. West, 1897a, p. 478; W. & G. S. West, 1898, p. 280; W. & G. S. West, 1904, p. 38, pl. 2, figs. 7–10; Borge, 1906, p. 12; Bernard, 1908, p. 57, f. 34; Printz, 1915, p. 6; Gronblad, 1920, p. 12; Smith, 1924, p. 6, pl. 52, f. 4; Donat, 1926, p. 4; Lowe, 1927, p. 306; Homfeld, 1929, p. 13; Borge, 1930, p. 21; Allorge, 1931, p. 343.

Length 138μ, breadth 20μ.

Dist.—Japan, Java, Canada, United States, Cuba, England, Wales, Scotland, Ireland, France, Germany, Austria, Italy, Norway, Spain, Sweden, Denmark, Russia, Poland, Nova Zembla, Spitzbergen, Finland.

Gen. **Mesotaenium** Näg., 1849.

Mesotaenium Kramstai Lemm.

(Pl. 17, fig. 4)

M. Kramstai Lemm. Nordst. 1896, p. 277; W. & G. S. West, 1904, p. 57, pl. 3, figs. 23, 24; Printz, 1915, p. 7.

Length 35μ, breadth 6μ.

Dist.—England, Norway, Germany.

New to Asia.

Gen. **Netrium** (Näg., 1849)

Netrium Digitus (Ehrenb.) Itzigs. & Rothe.

(Pl. 17. figs. 6, 11)

Closterium Digitus Ehrenb. Hass. 1845, p. 376, t. 88, f. 4.

Penium Digitus Bréb. Ralfs, 1848, p. 150, t. 25, f. 3; Delp. 1877, p. 86, t. 15, figs. 50, 51; Wolle, 1884, p. 34, t. 53, f. 1; Cooke, 1886, p. 40, t. 16, f. 1; W. West, 1892, p. 127; W. & G. S. West, 1898, p. 282; W. & G. S. West, 1902b, p. 134.

Netrium Digitus (Ehrenb.) Itzigs. & Rothe. Rabenh. 1856, no. 508; W. & G. S. West, 1904, p. 64, pl. 6, figs. 14–16; G. S. West, 1907, p. 107; Printz, 1915, p. 7; Grönblad, 1920, p. 12; Smith, 1924, p. 6, pl. 52, f. 5; Borge, 1925, p. 14; Donat, 1926, p. 5; Strom, 1926, p. 182; Woronichin, 1926, p. 218; Lowe, 1927, p. 307; Deflandre, 1928, p. 226; Homfeld, 1929, p. 14; Borge, 1930, p. 24; Allorge, 1931, p. 343.

Penium Digitus Bréb. f. *recta* Turn. Turn. 1893, p. 18, t. 1, f. 27.

P. Navigium Turn. Turn. 1893, p. 17, t. 1, f. 9.

Length 180μ, breadth 60μ.

Dist.—Japan, C. China, Java, Siam, Ceylon, India, Caucasus, Australia, New Zealand, Canada, United States, Brit. Guiana, Brazil, widely distributed in Europe, Azores.

Netrium Nägelii (Bréb.) W. & G. S. West.

(Pl. 17, fig. 13)

Penium Nägelii Bréb. Cooke, 1886, p. 42, t. 16, f. 4.

Netrium Nägelii (Bréb.) W. & G. S. West. W. & G. S. West, 1904, p. 66, pl. 7, figs. 4, 5; Printz, 1915, p. 8; Grönblad, 1920, p. 13; Strom, 1926, p. 183; Borge, 1930, p. 24; Skvortz, 1932, p. 147, pl. 1, f. 3.

Length 152μ, breadth 28μ.

Dist.—Korea, Australia, New Zealand, Brazil, England, Wales, Scotland, Ireland, France, Germany, Austria, Switzerland, Norway, Sweden, Finland, Lapland in Russia, E. Africa.

Netrium oblongum (De Bary) Lütkem.

(Pl. 17, fig. 5)

Penium oblongum De Bary. De Bary, 1858, pp. 42, 73, t. 7 g, figs. 1, 2; Delp. 1877, p. 86, t. 15, figs. 40–42; W. & G. S. West, 1902, p. 21.

Netrium oblongum (De Bary) Lütken. W. & G. S. West, 1904, p. 66, pl. 8, figs. 1–3; Printz, 1915, p. 8; Grönblad, 1920, p. 13; Borge, 1921, p. 12; Strom, 1922, p. 7; Donat, 1926, p. 5; Strom, 1926, p. 184; Woronichin, 1926, p. 218; Borge, 1930, p. 24; Allorge, 1931, p. 344.

Length 74μ, breadth 26μ.

Dist.—India, Caucasus, United States, Ecuador, Brazil, Faeroes, England, Wales, Scotland, Ireland, Germany, Austria, Hungary, Spain, Norway, Sweden, Lapland in Russia, W. & E. Africa, Somaliland.

New to Japan.

II. Placodermae

Gen. Penium Bréb., 1844.

Penium Cylindrus (Ehrenb.) Bréb.

(Pl. 17, fig. 8)

P. Cylindrus (Ehrenb.) Bréb. Ralfs, 1848, p. 150, t. 25, f. 2; Nordst. 1873, p. 44; Cooke, 1886, p. 39, t. 17, f. 2; W. West, 1892, p. 126; Nordst. 1896, p. 96; W. & G. S. West, 1902a, p. 21; W. & G. S. West, 1904, p. 84, pl. 6, figs. 1–3; Borge, 1906, p. 14; Printz, 1915, p. 8; Grönblad, 1920, p. 14; Donat, 1926, p. 5; Strom, 1926, p. 185; Homfeld, 1929, p. 15; Borge, 1930, p. 25; Allorge, 1931, p. 344.

Length 40μ, breadth 15μ.

Dist.—New Zealand, United States, Brazil, Faeroes, England, Wales, Scotland, Ireland, France, Germany, Austria, Italy, Switzerland, Norway, Sweden, Spain, Finland, Lapland in Russia.

New to Asia.

Penium Libellula (Focke) Nordst.

(Pl. 17, fig. 12)

P. closterioides Ralfs. Ralfs, 1848, p. 152, t. 34, f. 4; Wolle, 1884, p. 35, t. 5, f. 18; Cooke, 1886, p. 41, t. 16, f. 3; Nordst. 1888, p. 71; W. West, 1892, p. 127; Nordst. 1896, p. 75.

P. Libellula (Focke) Nordst. Turn. 1893, p. 20; W. & G. S. West, 1897b, p. 479; W. & G. S. West, 1902a, p. 21; W. & G. S. West, 1902b, p. 135; Borge, 1903, p. 74; W. & G. S. West, 1904, p. 73, pl. 7, figs. 6, 7; Borge, 1906, p. 14; Printz, 1915, p. 8; Dick, 1919, p. 232; Skvortz. 1932, p. 147, pl. 1, f. 4.

Length 169μ, breadth 30μ.

Dist.—Korea, Ceylon, Singapore, Java, C. China, New Zealand, Greenland, Brazil, Faeroes, England, Wales, Scotland, Ireland, France, Germany, Italy, Norway, Sweden, Austria, Hungary, Russia, Lapland.

Penium minutum (Ralfs) Cleve.

(Pl. 17, fig. 10)

Docidium minutum Ralfs. Ralfs, 1848, p. 158, t. 26, f. 5; Wolle, 1884, p. 52, t. 10, f. 9, t. 50, figs. 29–31; Cooke, 1886, p. 16, t. 8, f. 1.

Penium Ralfsii De Bary. De Bary, 1858, pp. 45, 73, t. 5, f. 8.

P. minutum (Ralfs) Cleve. Nordst. 1873, p. 45; Lagerheim, 1885, p. 253; Wolle, 1884, p. 35, t. 5, figs. 19, 20; W. West, 1892, p. 129 (*form*); Nordst. 1896, p. 172; W. & G. S. West, 1897b, p. 78; W. & G. S. West, 1897a, p. 479; W. & G. S. West, 1902a, p. 22; W. & G. S. West, 1902b, p. 136; Borge, 1903, p. 75; W. & G. W. West, 1904, p. 101, pl. 10, figs. 1, 2; Borge, 1906, p. 15; Smith, 1924, p. 8, pl. 52, f. 7; Borge, 1925, p. 15.

Pleurotaenium minutum Delp. Delp. 1877, p. 131, t. 20, figs. 17–21; De Toni, 1889, p. 904.

Calocylindrus minutus Kirchn. Wolle, 1884, p. 54, t. 12, f. 12.

Length 102–128μ, breadth 14–15μ, breadth of isthmus 12–13μ.

Dist.—Ceylon, United States, Cuba, Brit. Guiana, Brazil, England, Wales, Scotland, Ireland, France, Germany, Austria, Italy, Poland, Russia, Norway, Sweden, W. Africa.

New to Japan.

Penium minutum (Ralfs) Cleve var. *crassum* West.

(Pl. 17, fig. 9)

P. minutum (Ralfs) Cleve var. *crassum* West. W. West, 1892, p. 130, t. 20, figs. 1–3; W. & G. S. West, 1897b, p. 78; W. & G. S. West, 1898, p. 282; W. & G. S. West, 1902a, p. 22; Borge, 1903, p. 75, t. 1, f. 4; W. & G. S. West, 1904, p. 105, pl. 10, figs. 11–13.

Length 53μ, breadth 20–21μ.

Dist.—Brazil, Wales, Scotland, Ireland, Lapland, W. Africa.

New to Asia.

Penium rufescens Cleve.

(Pl. 17, fig. 3)

P. rufescens Cleve. Nordst. 1873, p. 45; Nordst. 1896, p. 227; W. & G. S. West, 1897a, p. 479; Borge, 1903, p. 75, t. 1, f. 6; W. & G. S. West, 1904, p. 99, pl. 6, figs. 12, 13; Printz, 1915, p. 9; Donat, 1926, p. 5; Strom, 1926, p. 186; Homfeld, 1929, p. 15.

P. rufopellitum Roy. Cooke, 1887, p. 185; W. West, 1892, p. 126.

Length 60μ, breadth 25μ.

Dist.—Brazil, England, Scotland, Ireland, Norway, Sweden, Germany.

New to Asia.

Penium spirostriolatum Barker.

(Pl. 17, fig. 7)

P. spirostriolatum Bark. Cooke, 1886, p. 39, t. 15, f. 9; Wolle, 1887, p. 22, t. 61, f. 19; W. West, 1892, p. 126; W. & G. S. West, 1897a, p. 478; W. & G. S. West, 1898, p. 282; G. S. West, 1899, pp. 377–380; W. & G. S. West, 1902a, p. 21; W. & G. S. West, 1902b, p. 136; W. & G. S. West, 1904, p. 88, pl. 9, figs. 1–8; Borge, 1906, p. 14; Printz, 1915, p. 8; Dick, 1919, p. 233; Donat, 1926, p. 5; Strom, 1926, p. 186; Homfeld, 1929, p. 16; Borge, 1930, p. 25; Allorge, 1931, p. 344, pl. 3, f. 8.

P. Royanum Turner. Turn. 1893, p. 165, t. 23, f. 7.

P. scandinavicum Turner. Turn. 1893, p. 166, t. 23, f. 6.

Length 112μ, breadth in middle 26μ, breadth (maximum) 29μ, breadth of apices 13μ.

Dist.—Ceylon, Java, United States, England, Wales, Scotland, Ireland, France, Germany, Austria, Hungary, Portugal, Denmark, Spain, Norway, Sweden, Finland.

New to Japan.

Gen. **Closterium** Nitzsch, 1817.

Closterium angustatum Kütz.

(Pl. 18, fig. 1)

Cl. angustatum Kütz. Ralfs, 1848, p. 172, t. 29, f. 4; Nordst. 1873, p. 40; Wolle, 1884, p. 40, t. 6, f. 21; Lagerheim, 1885, p. 254; Cooke, 1886, p. 30, t. 11, f. 3; Himerl, 1891, p. 592; W. West, 1892, p. 124; Nordst. 1896, p. 45; W. & G. S. West, 1897, p 482; W. & G. S. West, 1902a, p. 24; W. & G. S. West, 1904, p. 119, pl. 12, figs. 11–13; Bernard, 1908, p. 33; Printz 1915, p. 10; Dick, 1919, p. 237; Grönblad, 1920, t. 4, f. 41; Donat, 1926, p. 6; Woronichin, 1926, p. 218; Borge, 1930, p. 27; Allorge, 1931, p. 344.

Distance between apices 401μ, breadth 23μ.

Dist.—India, Caucasus, Java, United States, England, Wales, Scotland, Ireland, France, Germany, Spain, Austria, Italy, Norway, Sweden, Finland, Denmark, Lapland in Russia.

New to Japan.

Closterium attenuatum Ehrenb.

(Pl. 19, figs. 5, 5′)

Cl. attenuatum Ehrenb. Ralfs, 1848, p. 169, t. 29, f. 5; Wolle, 1884, p. 41, t. 8, f. 5; Cooke, 1886, p. 32, t. 14, f. 1; Nordst. 1888, p. 184; De Toni, 1889, p. 829; W. West, 1892, p. 124; Nordst. 1896, p. 54; W. & G. S. West, 1897a, p. 482; W. & G. S. West, 1902a, p. 24; W. & G. S. West, 1902b, p. 138; W. & G. S. West, 1904, p. 169, pl. 22, figs. 1–3; Borge, 1906, p. 16; Printz, 1915, p. 11, t. 1, f. 4; Dick, 1919, p. 237; Donat, 1926, p. 6; Homfeld, 1929, p. 17; Allorge, 1931, p. 344.

Length 495μ, breadth 45μ.

Dist.—Ceylon, United States, England, Wales, Scotland, Ireland, France, Germany, Austria, Galicia, Italy, Norway, Sweden, Denmark, Spain, Bornholm, N. Russia.

New to Japan.

Closterium costatum Corda.

(Pl. 18, fig. 2)

Cl. costatum Corda. Ralfs, 1848, p. 170, t. 21, f. 1; De-Notaries, 1867, p, 62; Nordst. 1873, p. 40; Wolle, 1884, p. 42, t. 6, f. 19; Lagerheim, 1885, p. 254; Cooke, 1886, p. 28, t. 10, f. 3; Nordst. 1888, p. 184; W. West, 1892, p. 123; Nordst. 1896, p. 85; W. & G. S. West, 1897a, p. 481; W. & G. S. West, 1902a, p. 24; W. & G. S. West, 1904, p. 120, pl. 13, figs. 1–3; Borge, 1906, p. 17; Printz, 1915, p. 10; Dick, 1919, p. 236; Grönblad, 1920, p. 16; Donat, 1926, p. 6; Woronichin, 1926, p. 218; Homfeld, 1929, p. 18; Allorge, 1931, p. 345.

Distance between apices 358μ, breadth 51μ.

Dist.—Caucasus, Greenland, United States, Cuba, Faeroes, England, Wales, Scotland, Ireland, France, Germany, Austria, Hungary, Spain, Italy, Norway, Sweden, Denmark, Finland, N. & S. Russia.

New to Japan.

Closterium Cynthia De Not.

(Pl. 18, fig. 8)

Cl. Cynthia De Not. De Not. 1867, p. 65, t. 7, f. 71; Nordst. 1873, p. 40; Cooke, 1886, p. 26, t. 13, f. 2; W. West, 1892, p. 123; W. & G. S. West, 1896, p. 237; Nordst. 1896, p. 96; W. & G. S. West, 1897a, p. 481; W. & G. S. West, 1902a, p. 24; W. & G. S. West, 1902b, p. 140; Borge, 1903, p. 79; W. & G. S. West, 1904, p. 113, pl. 11, figs. 1–3; Borge, 1907, p. 18; Printz, 1915, p. 9; Dick, 1919, p. 235; Grönblad, 1920, p. 16; Donat, 1926, p. 6; Strom, 1926, p. 188; Homfeld, 1929, p. 18.

Distance between apices 130μ, breadth 15μ.

Dist.—India, Ceylon, Sumatra, Australia, New Zealand, United States, Brazil, England, Wales, Scotland, Ireland, France, Germany, Austria, Hungary, Italy, Norway, Sweden, Finland, Denmark, E. Africa.

New to Japan.

Closterium Dianae Ehrenb.

(Pl. 18, fig. 5)

Cl. Dianæ Ehrenb. Hass. 1845, p. 371, t. 84, f. 5; Ralfs, 1848, p. 168, t. 28, f. 5; Nordst. 1873, p. 42; Klebs, 1879, p. 11; Cooke, 1886, p. 26, t. 13, f. 3; Nordst. 1888, p. 184; Himerl, 1891, p. 593; W. West, 1892, p. 122; Nordst. 1896, p. 104; W. & G. S. West, 1897a, p. 481; W. & G. S. West, 1898, p. 284; W. & G. S. West, 1902a, p. 23; W. & G. S. West, 1902b, p. 140; Cushman, 1903b, p. 513; Borge. 1903, p. 78; W. & G. S. West, 1904, p. 130, pl. 15, figs. 1–6; Borge, 1907, p. 18; Bernard, 1908, p. 34; G. S. West, 1912, p. 84; Printz, 1915, p. 10; Grönblad, 1920, p. 17; Donat, 1926, p. 6, pl. 3, f. 3; Strom, 1926, p. 188; Homfeld, 1929, p. 18; Allorge, 1931, p. 345.

Cl. acuminatum Kütz. Wolle, 1884, p. 44; De Toni, 1889, p. 840.

Distance between apices 288–290μ, breadth 20–21μ.

Dist.—Japan, Siberia, C. China, Ceylon, Siam, Java, Australia, New Zealand, Greenland, Cannada, United States, W. Indies, Brazil, Uruguay, Paraguay, Iceland, Faeroes, England, Wales, Scotland, Ireland, France, Germany, Austria, Galicia, Hungary, Italy, Portugal, Spain, Norway, Sweden, Finland, Denmerk, Bornholm, N., S. & C. Russia, Nova Zembla, Spitzbergen, C. & E. Africa.

Closterium didymotocum Corda.

(Pl. 19, fig. 6)

Cl. didymotocum Corda. Ralfs, 1848, pp. 168–169. t. 28, f. 7 a & b; Nordst. 1873, p. 39; Delp. 1877, p. 103, t. 17, figs. 31–37; Wolle, 1884, p. 39, t. 8, figs. 12, 13; Cooke, 1879a, p. 17, t. 8, f. 2 b & d; Himerl, 1891, p. 592; W. West, 1892, p. 120; Nordst. 1896, p. 107; W. & G. S. West, 1897a, p 479; W. & G. S. West, 1902a, p. 22; W. & G. S. West, 1904, p. 116, pl. 12, figs. 1–5; Borge, 1906, p. 16; Printz, 1915. p. 11; Dick, 1919, p. 231; Strom, 1922, p. 7; Donat, 1926, p. 6; Strom, 1926, p. 188; Woronichin, 1926, p. 218.

Cl. didymotocum Corda var. *Baillyanum* Bréb. Ralfs, 1848, p. 169, t. 28, figs. 7 c & d; Cooke, 1886, t. 8, figs. 2 a, c, e.

Cl. antiacerosum De Not. De Not. 1867, p. 61, t. 6, f. 63.

Cl. fractum Turn. Turn. 1893, p. 20.

Length 376μ, breadth 42μ.

Dist.—India, Caucasus, United States, England, Wales, Scotland, Ireland, France, Germany, Austria, Hungary, Italy, Norway, Sweden, Denmark, Finland, Lapland, Faeroes, E. Africa.

New to Japan.

Closterium gracile Bréb.

(Pl. 18, fig. 6)

Cl. gracile Bréb. Ralfs, 1848, p. 221; Nordst. 1873, p. 40; Wolle, 1884, p. 39, t. 6, figs. 4, 5; Cooke, 1886, p. 22, t. 13, f. 8; De Toni, 1889, p. 818; W. West, 1892, p. 122; Nordst. 1896, p. 132; W. & G. S. West. 1897a, p. 54; Borge, 1901, p. 18; W. & G. S. West, 1902a, p. 25; W. & G. S. West. 1902b, p. 138; Borge, 1903, p. 76; W. & G. S. West, 1904, p. 166, pl. 21, figs. 8–12; Borge, 1906, p. 16; Printz. 1915, p. 11; Gronblad, 1920, p. 18; Allorge, 1924, p. 463; Smith, 1924, p. 10; Borge, 1925, p. 16; Donat, 1926, p. 7; Strom, 1926, p. 188; Woronichin. 1926, p. 216; Lowe, 1927, p. 308; Deflandre, 1928, p. 228; Homfeld, 1929, p. 19; Allorge, 1931, p. 345, pl. 3, f. 11.

Length 160μ, breadth 5μ.

Dist.—Siberia, Ceylon, Siam, Sumatra, Caucasus, Australia, New Zealand, Greenland, Canada, United States, Brazil, Paraguay, Patagonia, Faeroes, Iceland, England, Wales, Scotland, Ireland, France, Germany, Austria, Galicia, Hungary, Portugal, Spain, Norway, Sweden, Denmark, N., S. & C. Russia, Finland, E. Africa.

New to Japan.

Closterium gracile Bréb. var. *elongatum* W. & G. S. West.

(Pl. 19, figs. 1, 2)

Cl. gracile Bréb. var. *elongatum* W. & G. S. West. W. & G. S. West, 1904, p. 168, pl. 21, figs. 14–16; Dick. 1919, p. 238; Smith, 1924, p. 11, pl. 53, f. 2; Donat, 1926, p. 7; Homfeld, 1929, p. 19, t. 11, f. 19.

Length 283–358μ, breadth 3–5μ.

Dist.—United States, Scotland, Ireland, Germany.

New to Asia.

Closterium intermedium Ralfs var. *hibernicum* West.

(Pl. 18, fig. 4)

Cl. intermedium Ralfs var. *hibernicum* West. W. & G. S. West, 1904, p. 126, pl. 14, f. 6; Donat, 1926, p. 7.

Length 267μ, breadth 19μ.

Dist.—England, Ireland, Germany.

New to Asia.

Closterium Jenneri Ralfs.

(Pl. 18, fig. 9)

Cl. Jenneri Ralfs. Ralfs, 1848, p. 167, t. 28, f. 6; Nordst. 1873, p. 42; Wolle, 1884, p. 44, t. 7, f. 5; Cooke, 1886, p. 24, t. 13, f. 4; Nordst. 1888, p. 184; De Toni, 1889, p. 843; Himerl, 1891, p. 593; W. West, 1892, p. 122; Nordst. 1896, p. 150; W. & G. S. West, 1902a, p. 24; W. & G. S. West, 1903, p. 525; Cushman, 1903b, p. 513; W. & G. S. West, 1904, p. 134, pl. 15, figs. 23–25; Borge, 1906, p. 18; G. S. West, 1907 p. 108; Bernard, 1908, p. 66, fig. 58; Printz. 1915, p. 10; Borge, 1925, p. 18; Donat, 1926, p. 7; Strom, 1926, p. 189; Lowe, 1927, p. 308; Borge, 1928, p. 98 (*form*); Borge, 1928, p. 98; Homfeld, 1929, p. 19; Borge, 1930, p. 28; Allorge, 1931, p. 345.

Length 80μ, breadth 9μ, breadth of apices 3μ, outer margin 171° of arc.

Dist.—Siam, Java, Greenland, Canada, United States, Brazil, Faeroes, England, Wales, Scotland, Ireland, France, Germany, Galicia, Hungary, Italy, Spain, Norway, Sweden, Bornholm, Nova Zembla, N. & S. Russia, C. & E. Africa, Azores.

New to Japan.

Closterium Kützingii Bréb.

(Pl. 19, fig. 3)

Cl. Kützingii Bréb. Nordst. 1873, p. 42; Nordst. 1880, p. 1; Wolle, 1884, p. 47, t. 8, f. 8; Cooke, 1886, p. 34, t. 5, f. 3; Roy & Bisset, 1886, p. 241; Nordst. 1888, p. 185; De Toni, 1889, p. 850; W. West. 1892, p. 125; W. & G. S. West, 1895, p. 47; Nordst. 1896, p. 152; W. & G. S. West, 1897a, p. 482; G. S. West, 1899; Borge, 1901, p. 20; W. & G. S. West, 1902a, p. 24; Borge, 1903, p. 80; W. & G. S. West, 1904, p. 186, pl. 25, figs. 6–11; Borge, 1906, p. 19; Bernard, 1908, p. 64, figs. 52–54; Printz, 1915, p. 12; Dick, 1919, p. 238; Grönblad, 1920, p. 18; Strom, 1921b, p. 14; Borge, 1921, p. 14; Smith, 1924, p. 12, pl. 53, f. 6; Borge, 1925, p. 19; Donat, 1926, p. 7; Strom, 1926, p. 189; Woronichin, 1926, p. 216; Homfeld, 1929, p. 19; Borge, 1930, p. 28.

Length 432μ, breadth 15μ, breadth of apices 3μ.

Dist.—Japan, India, Caucasus, Ceylon, Siam, Australia, New Zealand, Greenland, United States, Brazil, Ecuador, Paraguay, Patagonia, Faeraes, England, Wales, Scotland, Ireland, France, Germany, Austria, Galicia, Norway, Sweden, Bornholm, N. & C. Russia, Finland, Madagascar.

Closterium Lunula Ehrenb. var. *biconvexum* Schmidle.

(Pl. 19, fig. 7)

Cl. Lunula Ehrenb. var. *biconvexum* Schmidle. W. & G. S. West, 1904, p. 152, pl. 18, f. 11.

Length 470μ, breadth 78μ.

Dist.—Tyrol, Caucasus, England.

New to Japan.

Closterium parvulum Näg.

(Pl. 18, fig. 7)

Cl. parvulum Näg. De Bary, 1858, pp. 41, 42, 48–51. t. 5, figs. 14–23; Wolle, 1884, p. 45, t. 7, f. 7, t. 8, f. 16; De Toni, 1889, p. 841; Himerl, 1891 p. 593; Nordst. 1896, p. 196; W. & G. S. West, 1897a, p. 481; Borge, 1901, p. 18; W. & G. S. West, 1902a, p. 23; W. & G. S. West, 1903, p. 525; Borge, 1903, p. 79; W. & G. S. West, 1904, p. 133, pl. 15, figs. 9–12; Borge, 1906. p. 18; G. S. West, 1907, p. 108; Bernard, 1908, p. 68, figs. 65, 66; Printz, 1915, p. 10; Dick, 1919, p. 234; Borge, 1921, p. 14; Borge, 1925, p. 18; Donat, 1926, p. 8; Strom, 1926, p. 191; Woronichin, 1926, p. 218; Borge, 1928, p. 99; Borge, 1930, p. 28; Allorge, 1931, p. 346.

Length 105μ, breadth 11μ.

Dist.—Japan, Siberia, Ceylon, Siam, Sumatra, Java, Samoa, Caucasus, Australia, Greenland, United States, Brazil, Paraguay, Ecuador, Patagonia, England, Wales, Scotland, Ireland, France, Germany, Switzerland, Austria, Galicia, Hungary, Spain, Norway, Sweden, Denmark, Finland, N., S. & C. Russia, Nova Zembla, C. & E. Africa.

Closterium Ralfsii Bréb. var. *hybridum* Rabenh.

(Pl. 18, fig. 3)

Cl. Ralfsii Bréb. var. *hybridum* Rabenh. Nordst. 1873, p. 42; De Toni, 1889, p. 848; W. West, 1892, p. 124; W. & G. S. West, 1897a, p. 482; W. & G. S. West, 1897c, p. 159; W. & G. S. West, 1898, p. 284; W. & G. S. West, 1901, p. 166; W. & G. S. West, 1902b, p. 138; W. & G. S. West, 1904, p. 183, pl. 24, figs. 8–13; G. S. West, 1907, p. 110; Smith, 1924, p. 12, pl. 53, f. 5; Donat, 1926, p. 8; Lowe, 1927, p. 309; Homfeld, 1929, p. 23; Allorge, 1931, p. 346.

Cl. lineatum Ehrenb. var. *sandvicense* Nordst. 1878, p. 9, t. 1, figs. 10–12; Borge, 1894, p. 15.

Length 495μ, breadth 35μ.

Dist.—Ceylon, Siam, Singapore, Australia, New Zealand, Sandwich Is., Canada, United States, England, Ireland, Germany, Bohemia, Sweden, Spain, N. Russia, Africa.

New to Japan.

Closterium rostratum Ehrenb.

(Pl. 19, fig. 4)

Cl. rostratum Ehrenb. Hass. 1845, p. 373, t. 87, f. 6; Ralfs, 1848, p. 175, t. 30, f. 3; De Bary, 1858, pp. 50, 54, t. 5, figs. 26–30; De Notaris, 1867, p. 66; Nordst. 1873, p. 42; Delp. 1877, p. 118, t. 17, figs. 63–68; Klebs, 1879, p. 18; Wolle, 1884, p. 46, t. 8. figs. 1–3; Cooke, 1886, p. 33, t. 14, f. 3; Nordst. 1888, p. 185; De Toni, 1889, p. 851; W. West, 1892, p. 125; Nordst. 1896, p. 225; W. & G. S. West, 1897a, p. 482; W. & G. S. West, 1902a, p. 24; Borge, 1903, p. 80, t. 1, f. 27 (*form*); W. & G. S. West, 1904, p. 188, pl. 26, figs. 1–5; Borge, 1906, p. 19; Printz, 1915, p. 12; Dick, 1919, p. 238; Grönblad, 1920, p. 24; Grönblad, 1921, p. 8, pl. 5, f. 44; Borge, 1921, p. 14; Allorge, 1924, p. 463; Donat, 1926, p. 8; Strom, 1926, p. 191; Guerrero, 1927, p. 14; Lowe, 1927, p. 309; Homfeld, 1929, p. 24, t. 3, f. 25; Borge, 1930, p. 28; Allorge, 1931, p. 346, pl. 4, f. 4.

Length 360μ, breadth 26μ.

Dist.—Japan, Siberia, Ceylon (*form*), Greenland, Canada, United States, Brazil, Ecuador, Paraguay, Faeroes, England, Wales, Scotland, Ireland, France, Germany, Austria, Galicia, Hungary, Italy, Portugal, Spain, Norway, Sweden, Bornholm, Poland, N., S. & C. Russia, Finland, Iceland, Nova Zembla.

Gen. **Pleurotaenium** Näg., 1849.

Pleurotaenium coronatum (Bréb.) Rabenh. var. *fluctuatum* West.

(Pl. 20, fig. 2)

Pl. coronatum (Bréb.) Rabenh. var. *fluctuatum* West. W. West, 1892, p. 118, t. 19, f. 11; W. & G. S. West, 1904, p. 200, pl. 28, figs. 1, 2; Grönblad, 1920, p. 26.

Length 505μ, breadth at base of semicells 47–49μ, middle of semicells 42–45μ, apex 36μ.

Dist.—Scotland, Ireland, Finland.

New to Asia.

Pleurotaenium Ehrenbergii (Bréb.) De Bary.

(Pl. 20, figs. 3, 12)

Docidium Ehrenbergii Bréb. Ralfs. 1848, p. 157, t. 26, f. 4; Cooke, 1886, p. 14, t. 6, figs. 1 a, b. d.

Pleurotaenium Ehrenbergii (Bréb.) De Bary, 1858, p. 75; Nordst. 1873, p. 46; Lagerheim, 1885, p. 250; Nordst. 1888, p. 185; De Toni, 1889, p. 896; W. West, 1892,

p. 119; Nordst. 1896, p. 114; W. & G. S. West, 1897a, p. 483; W. & G. S. West, 1902a, p. 26; W. & G. S. West, 1902b, p. 145; Borge, 1903, p. 82; W. & G. S. West, 1904, p. 205, pl. 29, figs. 9–11, pl. 30, f. 1; W. & G. S. West, 1906, p. 99; G. S. West, 1907, p. 111; Printz, 1915, p. 13; Hig. 1916, p. 272; Grönblad, 1920, p. 26; Strom, 1921a, p. 8 (*form*); Strom, 1921b, p. 14; Borge, 1921, p. 15; Allorge, 1924, p. 463; Smith, 1924, p. 15, pl. 54, figs. 5–8; Donat, 1926, p. 9; Strom, 1926, p. 194; Lowe, 1927, p. 309; Borge, 1928, p. 99, t. 1, f. 9; Deflandre, 1928, p. 230; Homfeld, 1929, p. 26; Allorge, 1931, p. 347, pl. 4, figs. 2, 3.

Docidium Ehrenbergii Bréb. var. *tumidum* Turn. Turn. 1893, p. 31, t. 4, f. 4.

D. quantillum Turn. Turn. 1893, p. 28, t. 2, f. 9, t. 4, f. 12.

Length 397–425μ, breadth at the base of semicells 25–35μ, middle of semicells 21–35μ, apex 21μ.

Dist.—Japan, Siberia, C. China, India, Ceylon, Java, Sumatra, Samoa, Australia, New Zealand, Canada, United States, Brazil, Paraguay, Palagonia, England, Wales, Scotland, Ireland, France, Germany, Austria, Galicia, Hungary, Spain, Italy, Norway, Sweden, Denmark, Finland, Bornholm, Poland, N. Russia, Nova Zembia, Madagascar, E. & W. Africa.

Pleurotaenium Trabecula (Ehrenb.) Näg. var. *rectissimum* W. & G. S. West

(Pl. 20, fig. 8)

Pl. Trabecula (Ehrenb.) Näg. var. *rectissimum* W. & G. S. West. W. & G. S. West, 1904, p. 212, pl. 30, figs. 14, 15.

Length 265μ, breadth at base of semicells 25μ, middle of semicells 20μ, apex 15–17μ.

Dist.—Scotland.

New to Asia.

Pleurotaenium truncatum (Bréb.) Näg.

(Pl. 20, fig. 1)

Docidium truncatum Bréb. Ralfs, 1848, p. 156, t. 26, f. 2; Cooke, 1886, p. 15, t. 6, f. 4; Nordst. 1888, p. 185.

Pleurotaenium truncatum (Bréb.) Näg. De Bary, 1858, p. 75; Nordst. 1873, p. 47; Delp. 1877, p. 127, t. 19, figs. 7–11; De Toni, 1889, p. 897; W. West, 1892, p. 119; W. & G. S. West, 1897a, p. 483; Borge, 1903, p. 81; W. & G. S. West, 1904, p. 203, pl. 29, figs. 3, 4; Borge, 1906, p. 20; Dick, 1919, p. 239; Grönblad, 1920, p. 27; Strom, 1922, p. 8; Smith, 1924, p. 16, pl. 55, figs. 1, 2; Donat, 1926, p. 9; Strom, 1926, p. 195; Homfeld, 1926, p. 27; Allorge, 1931, p. 348.

Length 430μ, breadth (maximum) 70μ, breadth at apices 30–35μ, breadth of isthmus 55μ.

Dist.—India, New Zealand, Greenland, United States, Brazil, Paraguay, England, Wales, Scotland, Ireland, France, Germany, Austria, Galicia, Hungary, Italy, Norway, Sweden, Denmark, Spain, Finland, Bornholm, Poland, N. Russia, Nova Zembla, Spitzbergen.

New to Japan.

Gen. **Tetmemorus** Ralfs, 1844.

Tetmemorus Brébissonii (Menegh.) Ralfs. var. *minor* De Bary.

(Pl. 20, figs. 10, 11)

T. Brébissoni (Menegh.) Ralfs var. *minor* De Bary. De Bary, 1858, p. 73, t. 5, f. 9; Nordst. 1873, p. 39; Himerl, 1891, p. 594; W. & G. S. West, 1904, p. 218, pl. 32, figs. 4, 5; Borge, 1906, p. 21; Dick, 1919, p. 239; Grönblad, 1920, p. 28; Donat, 1926, p. 10; Strom, 1926, p. 195; Guerrero, 1927, p. 15; Homfeld, 1929, p. 28; Allorge, 1931, p. 348.

Length 77–80μ, breadth (maximum) 22μ, breadth of isthmus 17μ.

Dist.—Caucasus, England, Wales, Scotland, Ireland, Germany, Poland, Norway, Sweden, Finland, Denmark, Spain.

New to Japan.

Tetmemorus granulatus (Bréb.) Ralfs.

(Pl. 20, fig. 9)

T. granulatus (Bréb.) Ralfs. Hass. 1845, p 378, t. 89, f. 6; Ralfs. 1848, p. 147, t. 24, f. 2, t. 33, f. 1; De Bary, 1858, p. 29; De Notaris, 1867, p. 58; Nordst. 1873, p. 39; Lagerheim, 1885, p. 249; Cooke, 1886, p. 49, t. 18, f. 8, t. 19, f. 1; Nordst. 1888, p. 186; De Toni, 1889, p. 867; Himerl, 1891, p. 595; W. West, 1892, p. 132; Nordst, 1896, p. 135; W. & G. S. West, 1897a, p. 483; W. & G. S. West, 1902a, p. 26; W. & G. S. West, 1902b, p. 146; W. & G. S. West. 1904, p. 219, pl. 32, figs. 7–9; Borge, 1906, p. 21; Printz, 1915, p. 13; Dick, 1919, p. 239; Grönblad, 1920, p. 28; Strom, 1922, p. 8; Donat, 1926, p. 10; Strom, 1926, p. 196; Homfeld, 1929, p. 28; Allorge, 1931, p. 348.

Length 150μ, breadth 35μ, breadth of isthmus 30μ.

Dist.—China, Ceylon, Java, Australia, Sandwich Islands, Greenland, United States, W. Indies, England, Wales, Scotland, Ireland, France, Belgium, Germany, Austria, Galicia, Hungary, Italy, Portugal, Norway, Sweden, Spain, Finland, Denmark, Bornholm, N. & S. Russia, Iceland, Azores.

New to Japan.

Tetmemorus granulatus (Bréb.) Ralfs var. *attenuatus* West.

(Pl. 20, figs. 6, 7)

T. granulatus (Bréb.) Ralfs var. *attenuatus* West. W. West, 1892, p. 132, t. 20, f. 7; W. & G. S. West, 1896, p. 238; W. & G. S. West, 1902a, p. 27; W. & G. S. West, 1904, p. 221, pl. 32, f. 10; Donat, 1926, p. 10; Strom, 1926, p. 196.

Length 165μ, breadth (maximum) 29μ, breadth of isthmus 25μ, breadth of apex 15μ.

Dist.—United States, England, Wales, Scotland, Ireland, Sweden, Norway.

New to Asia.

Tetmemorus laevis (Kütz.) Ralfs.

(Pl. 20, figs. 4, 5)

T. laevis (Kütz.) Ralfs. Ralfs, 1848, p. 146, t. 24, f. 3; De Notaris, 1867, p. 59; Nordst. 1873, p. 35; Wolle, 1884, p. 91, t. 20, f. 3, t. 50, f. 35; Cooke, 1886, p. 49, t. 19, f. 2; Nordst. 1888, p. 186; De Toni, 1889, p. 868; Himerl, 1891, p. 595; W. West, 1892, p. 132; W. & G. S. West, 1894, p. 267; Nordst. 1896, p. 153; W. & G. S. West, 1897a, p. 483; Borge, 1901, p. 3; W. & G. S. West, 1902a, p. 27; Borge, 1903, p. 116; W. & G. S. West, 1904, p. 222, pl. 32, figs. 11–16; Borge, 1906, p. 21; Printz, 1915, p. 14; Dick, 1919, p. 238; Donat, 1926, p. 10; Strom, 1926, p. 196; Lowe, 1927, p. 309; Homfeld, 1929, p. 28, t. 3, f. 33; Allorge, 1931, p. 348.

Length 82–85μ, breadth 22μ, breadth of isthmus 17μ.

Dist.—Singapore, Australia, New Zealand, Greenland, Canada, United States, Dominica, Trinidad, W. Indies, Brazil, Patagonia, England, Wales, Scotland, Ireland, France, Belgium, Germany, Austria, Galicia, Italy, Norway, Sweden, Denmark, Spain, Bornholm, N. & S. Russia, Nova Zembla, Azores.

New to Japan.

Gen. **Euastrum** Ehrenb. 1832.

Euastrum aboense Elfv.

(Pl. 21, fig. 5)

E. aboense Elfv. De Toni, 1889, p. 1103; Nordst. 1896, p. 36; W. & G. S. West, 1905, p. 23, pl. 36, figs. 5, 6; Grönblad, 1920, p. 28; Grönblad, 1921, p. 17, pl. 13, figs. 39, 40; Allorge, 1931, p. 348, pl. 5, figs. 8, 9.

Length 73μ, breadth 45μ, breadth of isthmus 15μ.

Dist.—Finland, Wales, Scotland, Spain.

New to Asia.

Euastrum ansatum Ralfs.

(Pl. 22, fig. 9)

E. circulare Hass. Ralfs, 1848, p. 85, t. 14, f. 3a; Cooke, 1886, p. 71, t. 34, f. 2; De Toni, 1889, p. 1097.

E. ansatum Ralfs. Ralfs, 1848, p. 85, t. 14, f. 2; De-Notaris, 1867, p. 35; Nordst. 1873, p. 9; Lagerheim, 1885, p. 233; Cooke, 1886, p. 70, t. 33, f. 5; Nordst. 1888, p. 191; De Toni, 1889, p. 1096; Hiemerl, 1891, p. 601; W. West, 1892, p. 138; W. & G. S. West, 1895, p. 50, pl. 9, f. 17; Nordst. 1896, p. 46; W. & G. S. West, 1897a, p. 483; W. & G. S. West, 1902a, p. 28; W. & G. S. West, 1902b, p. 147; W. & G. S. West, 1903, p. 525; Borge, 1903, p. 110; W. & G. S. West, 1905a, p. 27, pl. 36, figs. 10–13; Borge, 1906, p. 24; Printz, 1915, p. 14; Dick, 1919, p. 248; Grönblad, 1920, p. 28; Borge, 1925, p. 22, t. 1, f. 44; Donat, 1926, p. 10; Strom, 1926, p. 197; Deflandre, 1928, p. 230; Homfeld, 1929, p. 28; Borge, 1930, p. 50; Allorge, 1931, p. 349.

E. ansatum Ralfs var. *sublobatum* Delp. Delp. 1873, p. 103, t. 6, figs. 35, 36.

Length 76μ, breadth 40μ, breadth of isthmus 12μ.

Dist.—Japan, C. China, India, Ceylon, Siam, Singapore, Sumatra, Java, Australia (*form*), New Zealand, Sandwich Islands, Greenland, United States, Cuba, Brazil, Paraguay, Faeroes, Iceland, England, Wales, Ireland, Scotland, France, Belgium, Germany, Austria & Galicia, Hungary, Spain, Italy, Norway, Sweden, Denmark, Bornholm, Finland, N. & S. Russia, Madagascar, Azores, E. Africa.

Euastrum bidentatum Näg.

(Pl. 22, fig. 4)

E. bidentatum Näg. W. & G. S. West, 1902a, p. 29; W. & G. S. West, 1905a, p. 39, pl. 37, figs. 16–19; Borge, 1906, p. 25; Printz, 1915, p. 15; Strom, 1921a, p. 7; Donat, 1926, p. 10; Strom, 1926, p. 198; Woronichin, 1926, p. 220; Lowe, 1927, p. 309; Homfeld, 1929, p. 28; Borge, 1930, p. 50; Allorge, 1931, p. 349.

E. elegans (Bréb.) Kütz. var. *bidentatum* (Näg.) Börg. Börg. 1889, p. 143, t. 6, f. 2; Borge, 1892, p. 6; W. & G. S. West, 1897, p. 483.

E. elegans (Bréb.) Kütz. var. *speciosum* Boldt. De Toni, 1889, p. 1102; Schmidle, 1865, p. 22.

Length 55μ, breadth 35μ, breadth of apex 25μ, breadth of isthmus 10μ.

Dist.—Caucasus, Greenland, Canada, United States, Brazil, Iceland, England, Wales, Scotland, Ireland, Germany, Norway, Finmark, Sweden, Denmark, Spain, Bornholn, Russia.

New to Japan.

Euastrum crassum (Bréb.) Kütz.

(Pl. 22, figs. 1, 2)

E. crassum (Bréb.) Kütz. Ralfs, 1848, p. 81, t. 11, f. 3; De-Notaris, 1867, p. 34; Nordst. 1873, p. 8; Wolle, 1884, p. 97, t. 25, figs. 1–3; Lagerheim, 1885, p. 232; Cooke, 1886, p. 65, t. 32, f. 1; De Toni, 1889, p. 1088; W. West, 1892, p. 136; W. & G. S. West, 1897a, p. 483; W. & G. S. West, 1902a, p. 27; W. & G. S. West, 1905a, p. 5, pl. 33, figs. 4–6; Borge, 1906, p. 22; Dick, 1919, p. 248; Grönblad, 1920, p. 30; Strom, 1921, p. 14; Smith, 1924, p. 22, pl. 56, f. 1; Donat, 1926, p. 11; Strom, 1926, p. 198; Homfeld, 1929, p. 29; Borge, 1930, p. 49; Allorge, 1931, p. 349, pl. 7, f. 1.

Length 168μ, breadth 82–88μ, breadth of isthmus 28μ, thickness 61μ.

Dist.—India, United States, Cuba, Faeroes, England, Wales, Scotland, Ireland, France, Germany, Galicia, Italy, Norway, Sweden, Spain, Denmark, Finland, Poland.

New to Japan.

Euastrum cuneatum Jenner.

(Pl. 23, fig. 3)

E. cuneatum Jenner. Ralfs, 1848, p. 90, t. 32, f. 3a; Nordst. 1873, p. 9; Lagerh. 1885, p. 233; Cooke, 1886, p. 76, t. 34, f, 6; Wolle, 1887, p. 37, t. 58, figs. 12, 13; W. West, 1892, p. 137; Nordst., 1896, p. 93; W. & G. S. West, 1897a, p. 483; W. & G. S. West, 1902a, p. 28; W. & G. S. West. 1905, p. 25, pl 36, f. 9; Dick. 1915, p. 248; Strom, 1926, p. 199, pl. 3, f. 4; Homfeld, 1929, p. 29; Borge, 1930, p. 52; Allorge, 1931, p. 349, pl. 6, f. 6.

Length 92μ, breadth 48μ, breadth of isthmus 15μ.

Dist.—Australia, Greenland, United States, England, Wales, Scotland, Ireland, France, Germany, Galicia in Austria, Norway, Spain, Sweden, N. Russia.

New to Asia.

Euastrum Didelta (Turp.) Ralfs. (*small form*)

(Pl. 21, fig. 3)

E. Didelta (Turp.) Ralfs. Hass. 1845, p. 381, t. 90, f. 8, t. 91, f. 11; Ralfs, 1848, p. 84, t. 14, f. 1; De-Notaris, 1867, p. 35; Nordst. 1873, p. 9; Delp. 1873, p. 105, t. 6, f. 2; Wolle, 1884, p. 99, t. 29, figs. 9–10; Cooke, 1886, p. 69, t. 34, f. 1; De Toni, 1889, p. 1093; Himerl, 1891, p. 601; W. West, 1892, p. 137; Nordst. 1896, p. 106; W. & G. S. West, 1897a, p. 483; G. S. West, 1899, p. 382, t. 8, figs. 13–19; W. & G. S. West, 1902a, p. 28; W. & G. S. West, 1902b, p. 147; Borge, 1903, p. 110; W. & G. S. West, 1905a, p. 15, pl. 35, figs. 3–7; Borge, 1906, p. 24; Printz, 1915, p. 14; Grönblad, 1920, p. 30; Strom, 1922, p. 8; Smith, 1924, p. 22, pl. 56, f. 2; Donat, 1926, p. 11; Strom, 1926, p. 199; Homfeld, 1929, p. 29; Borge, 1930, p. 50; Allorge, 1931, p 350.

Length 115μ, bereadth 65μ, breadth of isthmus 19μ.

Dist.—India, Ceylon, Greenland, United States, Paraguay, Faeroes, England, Wales, Scotland, Ireland, France, Germany, Austria, Galicia, Italy, Norway, Sweden, Spain, Denmark, Bornholm, Finland, N. & S. Russia, Azores.

New to Japan.

Euastrum dubium Näg.

(Pl. 23, fig. 8)

E. binale Ralfs. Ralfs, 1848, p. 90, t. 14, f. 8d.

E. dubium Näg. Nordst., 1896, p. 113; W. & G. S. West, 1905a, p. 43, pl. 38, figs. 5–8; Printz, 1915, p. 15; Dick, 1919, p. 249; Donat, 1926. p. 11; Strom, 1926, p. 200; Lowe, 1927, p. 309; Homfeld, 1929, p. 30; Borge, 1930, p. 51; Allorge, 1931, p. 350.

E. lobulatum Bréb. W. & G. S. West, 1902b, p. 29.

Length 26μ, breadth 18–28μ, breadth of apex 15μ, breadth of isthmus 7μ.

Dist.—Greenland, Canada, England, Wales, Scotland, Ireland, France, Germany, Norway, Sweden, Spain, Denmark, Italy.

New to Asia.

Euastrum elegans (Bréb.) Kütz. var. *pseudelegans* (Turn.) W. & G. West.

(Pl. 22, fig. 3)

E. pseudoelegans Turn. De Toni, 1889, p. 1102.

E. elegans (Bréb.) Kütz. var. *pseudelegans* (Turn.) W. & G. S. West. W. & G. S. West, 1905a, p. 49, pl. 38, figs. 22, 23.

Length 36μ, breadth 25μ, breadth of isthmus 7μ.

Dist.—United States, Wales.

New to Asia.

Euastrum gemmatum Bréb.

(Pl. 21, fig. 4)

E. gemmatum Bréb. Ralfs, 1848, p. 87, t. 14, f. 4; Nordst. 1873, p. 7; Wolle, 1884, p. 101, t. 28, figs. 3, 4; Cooke, 1886, p. 73, t. 35, f. 1; De Toni, 1889, p. 1070; W. West, 1892, p. 138; Nordst. 1896, p. 129; W. & G. S. West, 1902a, p. 28; W. & G. S. West, 1903, p. 525; Borge, 1903, p. 114; W. & G. S. West, 1905a, p. 63, pl. 39, f. 19; Borge, 1906, p. 26; Dick, 1919, p. 247; Grönblad, 1920, p. 31; Smith, 1924, p. 26, pl. 57, figs. 1, 2; Borge, 1925, p. 23; Strom, 1926, p. 201; Homfeld, 1929, p. 30; Allorge, 1931, p. 350.

Length 52μ, breadth 41μ, breadth of isthmus 10μ.

Dist.—India, Greenland, United States, W. Indies, Brazil, Paraguay, Faeroes, England, Wales, Scotland, France, Belgium, Germany, Galicia in Austria, Norway, Sweden, Spain, Denmark, Finland, Bornholm, Poland, S. Russia.

New to Japan.

Euastrum montanum W. & G. S. West.

(Pl. 23, fig. 2)

Cosmarium Subreinschii Schmid. W. & G. S. West, 1902a, p. 36.

Euastrum montanum W. & G. S. West. W. & G. S. West, 1905, p. 58, pl. 39, figs. 8, 9; Donat, 1926, p. 11; Strom, 1926, p. 201; Borge, 1930, p. 51; Allorge, 1931, p. 350, pl. 4, figs. 8–10.

Length 26μ, breadth 21μ, breadth of apex 15μ, breadth of isthmus 7μ.

Dist—Greenland, England, Wales, Scotland, Ireland, Bernese Alps, Germany, Norway, Sweden, Spain, Finnland.

New to Asia.

Euastrum obesum Josh.

(Pl. 23, fig. 1)

E. obesum Josh. Josh. 1886, p. 638, t. 23, figs. 19, 20; De Toni, 1889, p. 184; Nordst. 1896, p. 184; W. & G. S. West. 1905. p. 29, pl. 36, figs. 16, 17: Woronichin, 1926, p.218.

Length 86μ, breadth 42–44μ, breadth of apex 19μ, breadth of isthmus 14μ.

Dist.—India, Burma, Sumatra, Caucasus, England.

New to Japan.

Euastrum oblongum (Grev.) Ralfs.

(Pl. 21, fig. 7)

E. oblongum (Grev.) Ralfs. Ralfs, 1848, p. 80, t. 12; De-Notaris 1867, p. 34; Nordst. 1873, p. 7; Delp. 1873, p, 99, t. 6, figs. 26–30; Wolle, 1884, p. 98, t. 25, f. 5; Cooke, 1886, p. 64, t. 31, f. 2; Nordst. 1888, p. 190; De Toni, 1889, p. 1086; Himerl, 1891, p. 601; W. West, 1892, p. 136; Nordst. 1896, p. 185; W. & G. S. West, 1897a, p. 483; W. & G. S. West, 1902a, p. 27; W. & G. S. West, 1903, p. 525; W. & G. S. West, 1905a, p. 12, pl. 34, figs. 7–9, pl. 35, f. 2; Borge, 1906, p. 22; Printz, 1915, p. 14; Dick, 1919, p. 249; Grönblad, 1920, p. 87; Smith, 1924, p. 23, pl. 56, f. 3; Donat, 1926, p. 11; Strom, 1926, p. 202; Guerrero, 1927, p. 15; Lowe, 1927, p. 309; Homfeld, 1929, p. 31; Borge, 1930, p. 49.

Length 145μ, breadth 71μ, breadth of isthmus 22μ, breadth of polar tobe 40–42μ.

Dist.—Japan, Greenland, Canada, United States, Brazil, Faeroes, England, Wales, Scotland, Ireland, Franee, Germany, Galicia, Hungary, Italy, Norway, Sweden, Denmark, Bornholm, Finland, Poland, N., S. & C. Russia.

Euastrum pectinatum Bréb. var. *brachylobum* Wittr.

(Pl. 22, figs. 7, 8)

E. pectinatum Bréb. var. *brachylobum* Wittr. De Toni, 1889, p. 1068; W. & G. S. West, 1905, p. 62, pl. 39, f. 16; Printz, 1915, p. 16; Allorge, 1931, p. 351.

Length 67μ, breadth 51μ, breadth of polar lobe 32μ, breadth of isthmus 15μ.

Dist.—Scotland, Sweden, Spain, Norway.

New to Asia.

This is one of the rarest species of Desmids in the Northern Kurile districts.

Euastrum pinnatum Ralfs.

(Pl. 24, fig. 5)

E. pinnatum Ralfs. Ralfs, 1848, p. 81, t. 13, f. 1; Nordst. 1873, p. 8; Wolle, 1884, p. 98, t. 28, figs. 14–16; Lagerh. 1885, p. 233; Cooke, 1886, p. 66, t. 32, f. 2; De Toni, 1889, p. 1089; W. West, 1892, p. 137; Nordst. 1896, p. 201; W. & G. S. West, 1902a, p. 28; W. & G. S. West, 1905a, p. 10, pl. 34, figs. 3–6; Borge, 1906, p. 23; Printz, 1915, p. 14; Grönblad, 1920, p. 31; Smith, 1924, p. 24, pl. 56, f. 5; Donat, 1926, p. 12; Strom, 1926, p. 203, pl. 3, f. 5; Homfeld, 1929, p. 31; Borge, 1930, p. 49; Allorge, 1931, p. 351.

Length 127μ, breadth 65μ, breadth of isthmus 20μ.

Dist.—United States, Faeroes, England, Wales, Scotland, Ireland, France, Germany, Galicia in Austria, Norway, Sweden, Spain, Finland.

New to Asia.

Euastrum sinuosum Lenorm. var. *reductum* W. & G. S. West.

(Pl. 23, fig. 6)

E. sinuosum Lenorm. var. *reductum* W. & G. S. West. W. & G. S. West, 1897b, p. 83; W. & G. S. West, 1897c, p. 160, t. 8, f. 17; W. & G. S. West, 1902b, p. 148; W. & G. S. West, 1905a, p. 22, pl. 36, figs. 2, 3; Strom, 1926, p. 203, pl. 4, f. 1; Allorge, 1931, p. 351, pl. 5, figs. 6, 7.

Length 61μ, breadth 37–39μ, breadth of isthmus 12μ.

Dist.—Ceylon, Singapore, England, Ireland, Norway, Spain, W. Africa.

New to Japan.

Euastrum sublobatum Bréb.

(Pl. 23, fig. 7)

E. sublobatum Bréb. Ralfs, 1848, p. 91, t. 32, f. 4; Nordst. 1873, p. 10; Nordst. 1896, p. 245; W. & G. S. West, 1905a, p. 73, pl. 40, f. 19; Printz, 1915, p. 16; Grönblad, 1920, p. 32; Srom, 1926, p. 203.

Cosmarium sublobatum (Bréb.) Arch. Wolle, 1884, p. 80, t. 18, figs. 21, 23; Cooke, 1886, p. 79, t. 36, f. 1; De Toni, 1889, p. 1041; W. & G. S. West, 1902a, p. 32.

Length 27μ, breadth 20μ, breadth of apex 15μ, breadth of isthmus 6μ.

Dist.—Greenland, United States, W. Indies, England, Wales, Scotland, Ireland, France, Germany, Galicia, Austria, Hungary, Italy, Norway, Poland, S. Russia, Finland.

New to Asia.

Euastrum verrucosum Ehrenb. var. *reductum* Nordst.

(Pl. 24, fig. 3)

E. verrucosum Ehrenb. var. *reductum* Nordst. De Toni, 1889, p. 1067; W. & G. S. West, 1902a, p. 27; W. & G. S. West, 1903, p. 525; W. & G. S. West, 1905, p. 65, pl. 40, figs. 2, 3.

Length 90–92μ, breadth 80–86μ, breadth of isthmus 22μ.

Dist.—United States, Uruguay, Argentina, Scotland, Ireland, Norway, N. Russia.

New to Asia.

Euastrum verrucosum Ehrenb. var. *rhomboideum* Lund.

(Pl. 21, fig. 6)

E. verrucosum Ehrenb. var. *rhomboideum* Lund. De Toni, 1889, p. 1067, Borge, 1923, p. 16, pl. 2, f. 17; Strom, 1926, p. 203; Homfeld, 1929, p. 32, pl. 4, f. 36.

Length 118μ, breadth 110–112μ, breadth of isthmus 22μ, breadth of polar lobe 40–42μ.

Dist.—United States, Germany, Norway, Sweden.

New to Asia.

Gen. **Micrasterias** Ag. 1827.

Micrasterias Americana (Ehrenb.) Ralfs.

(Pl. 25, fig. 3)

M. Americana (Ehrenb.) Ralfs. Ralfs, 1848, p. 19; Nordst. 1872, p. 6; Wolle, 1884, p. 112, t. 32, f. 2; Cooke, 1886, p. 56, t. 30, f. 1; Nordst. 1888, p. 187; De Toni, 1889, p. 1134; W. West, 1892, p. 134; Nordst. 1896, p. 42; W. & G. S. West, 1897a, p. 484; W. & G. S. West, 1903, p. 526; W. & G. S. West, 1905a, p. 117, pl. 53, figs. 4, 5, pl. 54, figs. 1–3; Borge, 1906, p. 28; Grönblad, 1920, p. 33; Smith, 1924, p. 52, pl. 63, f. 5; Strom, 1926, p. 203; Lowe, 1927, p. 310; Homfeld, 1929, p. 33.

Length 155μ, breadth 125μ, breadth of polar lobe (maximum) 70μ, breadth of isthmus 25μ.

Dist.—N. India, Greenland, Canada, United States, England, Wales, Scotland, Ireland, France, Germany, Galicia, Hungary, Norway, Sweden, Bornholm, Finland, Poland, E. Africa.

New to Japan.

Micrasterias Crux-melitensis (Ehrenb.) Hass.

(Pl. 25, fig. 4)

M. Crux-melitensis (Ehrenb.) Hass. Hass. 1845, p. 386, t. 90, f. 7; Ralfs, 1848, p. 73, t. 9, f. 3; De Bary, 1858, p. 41; Delp. 1873, p. 87, t. 4, f. 7; Wolle, 1884, p. 111, t. 35, f. 3; Cooke, 1886, p. 55, t. 21, f. 2; Nordst. 1888, p. 190; De Toni, 1889, p. 1113; Himerl, 1891, p. 602; W. West, 1892, p. 133; Nordst. 1896, p. 90; W. & G. S. West, 1902b, p. 157; Borge, 1903, p. 119; W. & G. S. West, 1905a, p. 116, pl. 53, figs. 1–3; Borge, 1906, p. 27; Printz, 1915, p. 17; Dick, 1919, p. 250; Grönblad, 1920, p. 35, t. 6, figs. 19, 20; Grönblad 1921, p. 22; Allorge, 1924, p. 465; Donat, 1926, p. 12; Borge, 1928, p. 104 (*form.*); Homfeld, 1929, p. 34, t. 4, f. 38; Allorge, 1931, p. 351.

Length 125μ, breadth 118μ, breadth of isthmus 21μ, breadth of polar lobe (maximum) 51μ.

Dist.—Japan, N. India, Ceylon, Burma, Celebes, United States, Brazil, England, Wales, Scotland, Ireland, France, Germany, Austria, Galicia, Hungary, Italy, Sweden, Spain, Denmark, Poland, Finland, N. & S. Russia, E. & C. Africa.

Micrasterias denticulata Bréb.

(Pl. 26, fig. 10)

M. denticulata Bréb. Ralfs, 1848, p. 70, t. 7, f. 1; De Bary, 1858, p. 41; De-Notaris, 1867, p. 31; Nordst. 1873, p. 5; Wolle, 1884, p. 109, t. 34, figs. 4–8; Roy & Biss. 1886, p. 193; Cooke, 1886, p. 56, t. 22; Nordst. 1888, p. 187; De Toni, 1889, p. 1130; W. West, 1892, p. 134; Nordst. 1896, p. 99; W. & G. S. West, 1897a, p. 484; G. S. West 1899, p. 384; W. & G. S. West, 1902a, p. 30; Borge, 1903, p. 119; W. & G. S. West, 1905a, p. 105, pl. 49, figs. 1–7, pl. 50, figs. 1, 2; Dick, 1919, p. 250; Grönblad, 1920, p. 35; Grönblad, 1921, p. 25; Smith, 1924, p. 45, pl. 59, f. 5; Donat, 1926, p. 13; Strom, 1926,p. 204; Homfeld, 1929, p. 34; Borge, 1930, p. 53; Allorge, 1931, p. 351.

Length 208μ, breadth 178μ, breadth of isthmus 30μ, breadth of polar lobe 55μ.

Dist.—Japan, India, Sumatra, Australia, New Zealand, Greenland, United States, Brazil, Faeroes, England, Wales, Scotland, Ireland, France, Germany, Austria, Galicia, Hungary, Italy, Norway, Sweden, Spain, Denmark, Bornholm, Finland, N., S. & C. Russia.

Micrasterias denticulata Bréb. var. *angulosa* (Hantzsch) W. & G. S. West.

(Pl. 21, fig. 1)

M. angulosa Hantzsch. Cook. 1886, p. 62, t. 29; De Toni, 1889, p. 1133.

M. denticulata Bréb. var. *angulosa* (Hantz.) W. & G. S. West. W. & G. S. West, 1902a, p. 30; W. & G. S. West, 1905a, p. 107, pl. 50, figs. 3, 4; Strom, 1926, p. 204; Allorge, 1931, p. 351.

Length 225μ, breadth 185μ, breadth of isthmus 28μ, breadth of polar lobe (maximum) 62μ.

Dist.—New Zealand, Greenland, England, Wales, Scotland, Ireland, France, Germany, Galicia in Austria, Norway, Sweden, Denmark, Spain, Bornholm.

New to Asia.

Micrasterias denticulata Bréb. var. *angustosinuata* Gay.

(Pl. 25, fig. 6)

M. denticulata Bréb. var. *angustosinuata* Gay. W. & G. S. West, 1905a, p. 108, pl. 50, f. 5.

Length (semicell) 110μ, breadth 172μ, breadth of isthmus 35μ.

Dist.—England, Scotland, France.

New to Asia.

Micrasterias denticulata Bréb. var. *notata* Nordst.

(Pl 24, fig. 4)

M. denticulata Bréb. var. *notata* Nordst. W. & G. S. West, 1905a, p. 108, pl. 50, f. 6; Borge, 1906, p. 27; Borge, 1925, p. 26, t. 5, f. 1.

Length 208μ, breadth 192μ, breadth of isthmus 28μ, breadth of polar lobe 48–52μ.

Dist.—New Zealand, Brazil, England, Scotland, Germany, Sweden, Finland.

New to Asia.

Microsterias denticulata Bréb. var. *notata* Nordst. forma *minor forma nov.*

(Pl. 24, fig. 6)

Cells less than two-thirds the size of the typical form; lateral lobes broadly cuneate, with acute angles; polar lobe with a pair of short spines (sometimes four spines) on each side of apex; cell-wall minutely punctate. Zygospore unknown.

Length 128μ, breadth 161μ, breath of isthmus 27μ, breadth of polar lobe 41–46μ.

Loc.—Shiginosu-daira, Paramushir Is.

Micrasterias papillifera Bréb.

(Pl. 25, figs. 1, 2)

M. papillifera Bréb. Ralfs, 1848, p. 72, t. 9, f. 1; Nordst. 1873, p. 5; Delp. 1873, p. 86, t. 4, figs. 5, 6; Wolle, 1884, p. 109; Cook. 1886, p. 60, t. 27, f. 2; De Toni, 1889, p. 1132; W. West, 1892, p. 135; Nordst. 1896, p 194; W. & G. S. West, 1897a, p. 484; W. & G. S. West, 1902a, p. 30; W. & G. S. West, 1905a, p. 91, pl. 44, figs. 1, 2, 7; Printz, 1915, p. 17; Higashi, 1916, p. 282; Dick, 1919, p. 251; Grönblad, 1920, p. 36, t. 6, figs. 9, 10; Strom, 1921a, p. 8; Strom, 1921b, p. 14; Donot, 1926, p. 13; Strom, 1926, p. 204; Woronichin, 1926, p. 218; Lowe, 1927, p. 309; Homfeld, 1929, p. 35; Allorge, 1931, p. 352.

Length 130μ, breadth 116–118μ, breadth of polar lobe 35–41μ, breadth of isthmus 20μ.

Dist.—Japan, Caucasus, New Zealand, Greenland, Canada, United States, Brazil, England, Wales, Scotland, Ireland, France, Germany, Austria, Galicia, Hungary, Italy, Norway, Sweden, Spain, Denmark, Bornholm, Finland, N. & S. Russia, Russian Lapland.

Micrasterias pinnatifida (Kütz.) Ralfs.

(Pl. 21, fig. 2)

M. pinnatifida (Kütz.) Ralfs. Ralfs. 1848, p. 77, t. 10, f. 3; De-Notaris, 1867, p. 31; Nordst. 1873, p. 6; Wolle, 1884, p. 116, t. 37, figs. 7, 8; Cook. 1886, p. 54, t. 20, f. 3; Roy & Bisset, 1886, p. 193; Nordst. 1888, p. 186; Himerl, 1891, p. 602; W. West, 1892, p. 133; Nordst. 1896, p. 201; W. & G. S. West, 1896, p. 238, t. 13, f. 28; W. & G. S. West, 1902a, p. 30; W. & G. S. West, 1902b, p. 156; W. & G. S. West, 1903, p. 526; W. & G. S. West, 1905a, p. 80, pl. 41, figs. 7–11, 13; Printz, 1915, p. 16; Dick, 1919, p. 250; Grönblad, 1920, p. 36; Smith, 1924, p. 41, pl. 59, figs. 1, 2; Borge, 1925, p. 26; Donat, 1926, p. 13; Homfeld, 1929, p. 35; Borge, 1930, p. 53.

M. oscitans Ralfs. var. *pinnatifida* Rabenh. De Toni, 1889, p. 1110.

Length 70μ, breadth 73μ, breadth of isthmus 12μ, breadth of polar lobe 45–50μ.

Dist.—Japan, India, Ceylon, United States, W. Indies, Brazil, Faeroes, England, Wales, Scotland, Ireland, France, Germany, Austria, Norway, Sweden, Denmark, Bornholm, Finland, Poland.

Micrasterias rotata (Grev.) Ralfs.

(Pl. 23, figs. 4, 5)

M. rotata (Grev.) Ralfs. Hass. 1845, p. 385, t. 90, f. 1; Ralfs. 1848, p. 71, t. 8, f. 1a; De-Notaris, 1867, p. 30; Nordst. 1873, p. 5; Delp. 1873, p. 82, t. 4, f. 1; Wolle, 1884, p. 109, t. 34, figs. 1, 2; Cook. 1886, p. 57, t. 24; Nordst. 1888, p. 187; De Toni, 1889, p. 1126; Himerl, 1891, p. 603; Nordst. 1896, p. 226; W. & G. S. West, 1897c, p. 163; W. & G. S. West, 1902a, p. 30; W. & G. S. West, 1903, p. 525; Borge, 1903, p. 119; W. & G. S. West, 1905a, p. 102, pl. 48, figs. 1–6; Printz, 1915, p. 17; Dick, 1919, p. 251; Grönblad, 1920, p. 37; Grönblad, 1921, p. 23; Donat, 1926, p. 13; Strom, 1926, p. 204; Woronichin, 1926, p. 218; Borge, 1928, p. 103; Deflandre, 1928, p. 233; Homfeld, 1929, p. 36; Borge, 1930,p. 53; Allorge, 1931, p. 352.

Length (semicell) 135μ, breadth 125–127μ, breadth of isthmus 37–40μ, breadth of polor lobe (maximum) 60–68μ.

Dist.—Japan, India, Siam, Singapore, Caucasus, United States, Brazil, England, Wales, Scotland, Ireland, France, Germany, Austria, Galicia, Hungary, Italy, Norway, Sweden, Spain, Denmark, Bornholm, Finland, Poland, S. & C. Russia, Africa.

Micrasterias Thomasiana Arch.

(Pl. 22, figs. 5, 6)

M. Thomasiana Arch. Nordst. 1873, p. 5; Cooke, 1886, p. 58, t. 25, f. 1; W. & G. S. West, 1896, p. 241; Nordst. 1896, p. 254; W. & G. S. West, 1897c, p. 163; G. S. West, 1899, p. 384, t. 9, figs. 6–8; W. & G. S. West, 1902a, p. 30; W. & G. S. West, 1902b, p. 157; W. & G. S. West, 1905a, p. 110, pl. 51, figs. 3–6; Borge, 1906, p. 27; G. S. West, 1909, p. 58; Printz, 1915, p. 17; Strom, 1921b, p. 14; Grönblad, 1921, p. 27 (*form*); Allorge, 1924, p. 465; Smith, 1924, p. 48, pl. 60, f. 5; Strom, 1926, p. 205; Homfeld, 1929, p. 36; Borge, 1930, p. 53; Allorge, 1931, p. 352, pl. 8, f. 6.

Length 190–225μ, breadth 178–200μ, breadth of isthmus 25–31μ, breadth of polar lobe 45–48μ.

Dist.—Ceylon, Singapore, United States, England, Scotland, Ireland, France, Germany, Galicia in Austria, Norway, Sweden, Spain.

New to Japan.

Micrasterias truncata (Corda) Bréb.

(Pl. 24, figs. 1, 2; Pl. 25, fig. 5)

M. truncata (Corda) Bréb. Ralfs, 1848, p. 75, t. 8, f. 4, t. 10, f. 5; De-Notaris, 1867, p. 32; Nordst. 1873, p. 7; Delp. 1873, p. 89, t. 5, figs. 6–10; Wolle, 1884, p. 114, t. 38, f. 6; Lagerheim, 1885, p. 230; Cook. 1886, p. 60, t. 25, f. 2; Nordst. 1888, p. 187; De Toni, 1889, p. 1115; Himerl, 1891, p. 602; W. West, 1892, p. 135; Nordst. 1896, p. 260; W. & G. S. West, 1897a, p. 484; G. S. West, 1899, p. 383, t. 9, figs. 9–16; W. & G. S. West, 1902a, p. 30: Borge, 1903, p. 118; W. & G. S. West, 1905a, p. 82, pl. 42, figs. 1–8, pl. 45, figs. 5, 6; Borge, 1906, p. 26; Printz, 1915, p. 17; Dick, 1919, p. 250; Grönblad, 1920, p. 38; Smith, 1924, p. 43, pl. 60, figs. 1, 2; Donat, 1926, p. 13; Strom, 1926, p. 205; Woronichin, 1926, p. 218; Guerrero, 1927, p. 18; Homfeld, 1929, p, 36, t. 5, f. 45; Borge, 1930, p. 53, t. 1, f. 19; Allorge, 1931, p. 352, pl. 6, figs. 1, 2.

M. quadragies-cuspidata (Corda) Ralfs. Ralfs, 1848, p. 209.

M. truncata var. *euastroides* De Toni. De Toni, 1889, p. 1115.

Length 77–105μ, breadth 72–796μ, breadth of polar lobe 52–68μ, breadth of isthmus 20–25μ.

Dist.—Japan, N. India, Caucasus; Sandwich Islands, United States, Cuba, Brazil, Faeroes, England, Wales, Scotland, Ireland, France, Germany, Austria, Galicia, Hungary, Italy, Norway, Sweden, Spain, Denmark, Bornholm, Finland, Poland (*form*), N. & S. Russia.

Gen. Cosmarium Corda, 1834.

Cosmarium Boeckii Wille.

(Pl. 26, fig. 4)

C. Boeckii Wille. Cook. 1887, p. 111, t. 42, f. 4; Nordstedt, 1888, p. 196; De Toni, 1889, p. 1024; Himerl, 1891, p. 597; W. West, 1892, p. 157; W. & G. S. West, 1896, p. 251, t. 15, f. 7; W. & G. S. West, 1902a, p. 38; W. & G. S. West, 1908, p. 234, pl. 86, figs. 26–32; Printz, 1915, p. 30; Dick, 1919, p. 246; Grönblad, 1920, p. 40; Borge, 1921, p. 16; Allorge, 1924, p. 466; Donat, 1926, p. 17; Strom, 1926, p. 206; Homfeld, 1929, p. 39, t. 5, f. 50.

C. anisochondrum Nordst. forma. Borge, 1906, p. 32, t. 2, f. 17.

Length 37μ, breadth 29–30μ, breadth of isthmus 9μ.

Dist.—Japan, United States, Faeroes, Iceland, England, Wales, Scotland, Ireland, France, Germany, Galicia, Norway, Denmark, Sweden, Bornholm, Finland, Poland.

Cosmarium Botrytis Menegh.

(Pl. 27, fig. 15)

C. Botrytis Menegh. Hass. 1845, p. 363, t. 86, f. 2; Ralfs, 1848, p. 99, t. 16, f. 1; De Bary, 1858, pp. 38, 45–51, 72, t. 6, figs. 1–24; De-Notaris, 1867, p. 45; Nordstedt, 1873, p. 12; Delp. 1873, p. 22, t. 8, figs. 31–39; Klebs, 1879, p. 38, t. 3, figs. 62, 63; Cooke, 1887, p. 105, t. 39, f. 4; De Toni, 1889, p. 979; Himerl, 1891, p. 596; West, 1892, p. 155; Nordst. 1896, p. 64; Borge, 1896b, p. 293; Borge, 1901, p. 20; W. & G. S. West, 1902a, p. 39; W. & G. S. West, 1903, p. 527; W. & G. S. West, 1905b, p. 484; W. & G. S. West, 1906, p. 85; Borge, 1906, p. 30; Bernard, 1908, p. 96, figs. 132, 133; W. & G. S. West, 1911, p. 1, pl. 96 figs. 1, 2, 5–15; G. S. West, 1912, p. 85; Printz, 1915, p. 30; Dick, 1919, p. 245; Grönblad 1920, p. 40; Strom, 1921a, p. 7; Strom, 1921b, p. 16; Borge, 1921, p. 15; Allorge, 1924, p. 466; Smith, 1924, p. 33, pl. 57, f. 22; Donat, 1926, p. 17; Strom, 1926, p. 206; Guerrero, 1927, p. 15; Homfeld, 1929, p. 39; Borge, 1930, p. 29; Allorge, 1931, p. 354; Borge, 1933, p. 13 (*form*).

Length 82μ, breadth 67–70μ, breadth of isthmus 22μ.

Dist.—Japan, Siberia, Mongolia, China, Ceylon, Java, New Zealand, Greenland, United States, Brazil, Argentina, Patagonia, Faeroes, Iceland, England, Wales, Scotland, Ireland, France, Belgium, Germany, Austria, Galicia, Roumania, Bosnia, Hungary, Italy, Portugal, Norway, Sweden, Spain, Denmark, Bornholm, Finland, Poland, N. & S. Russia, Nova Zembla, Spitzbergen, Azores.

Cosmarium caelatum Ralfs var. *spectabile* (De Not.) Nordst.

(Pl. 27, fig. 13)

C. spectabile De Not. De Not. 1867, p. 45. t. 4, f. 31.

C. caelatum Ralfs var. *spectabile* (De Not.) Nordst. De Not. 1867, p. 40; Nordstedt, 1888, p. 197; De Toni, 1889, p. 1008; Borge, 1906, p. 41; W. & G. S. West, 1908, p. 136, pl. 76, f. 8; Borge, 1930, p. 38.

Length 46μ, breadth 46μ, breadth of isthmus 18μ.

Dist.—Wales, Scotland, France, Italy, Austria, Galicia, Sweden.

New to Asia.

Cosmarium contractum Kirchn. var. *ellipsoideum* (Elfv.) W. & G. S. West.

(Pl. 27, fig. 8)

C. ellipsoideum Elfv. De Toni, 1889, p. 953; W. & G. S. West, 1897a, p. 491.

C. contractum Kirchn. var. *ellipsoideum* (Elfv.) W. & G. S. West. W. & G. S. West, 1902a, p. 40; W. & G. S. West, 1905a, p. 172, pl. 61, figs. 28, 35; Borge, 1906, p. 38; G. S. West, 1907, p. 116; Printz, 1915, p. 20; Strom, 1921b, p. 16; Donat, 1926, p. 14; Strom, 1926, p. 207, pl. 5, f. 4; Borge, 1930, p. 35.

Length 38μ, breadth 32–33μ, breadth of isthmus 11μ.

Dist.—Australia, Faeroes, Iceland, England, Wales, Scotland, Ireland, Sweden, Norway, Finland, N. Russia, Portugal, Africa.

New to Asia.

Cosmarium Cucurbita Bréb.

(Pl. 26, fig. 7)

C. Cucurbita Bréb. Ralfs. 1848, p. 108. t. 17, f. 7; Nordst., 1873 p. 24; Klebs, 1879, p. 28; W. West, 1892, p. 162; W. & G. S. West, 1894, p. 268; Nordst. 1896, p. 92; W. & G. S. West, 1897a, p. 492; W. & G. S. West, 1902a, p. 41; Borge, 1906, p. 35; W. & G. S. West, 1908, p. 106, pl. 73, figs. 31–33, pl. 74, f. 3; Printz, 1915, p. 26; Grönblad, 1921, p. 43, pl. 7, f. 63; Borge, 1921, p. 16; Strom, 1926, p. 208; Homfeld, 1929, p. 41; Borge, 1930, p. 32; Allorge, 1931, p. 355; Borge, 1933, p. 13.

Dysphinctium Cucurbita (Bréb.) Grun. De Toni, 1889, p. 881; Turn. 1893, p, 44.

Cilocylindrus Cucurbita (Bréb.) Kirchn. Wolle, 1884, p. 54, t. 12, f. 14; Cooke, 1887, p. 125, t. 44, f. 7.

Cosmarium Palangula Bréb. var. *Debaryi* Rabenh. Nordst. 1878, p. 13; W. West, 1892, p. 162; Borge, 1906, p. 35.

Length 44μ, breadth 22μ, breadth of isthmus 17.5μ.

Dist.—China, Singapore, Australia, Greenland, United States, W. Indies, Brazil, Faeroes, England, Scotland, Ireland, France, Germany, Austria, Galicia, Hungary, Spain, Italy, Norway, Sweden, Denmark, Finland, Poland, N. & S. Russia, W. Africa.

New to Japan.

Cosmarium cyclicum Lund. var. *arcticum* Nordst.

(Pl. 26, fig. 8)

C. cyclicum Lund. var. *arcticum* Nordst. Nordst. 1873, p. 16; De Toni, 1889, p 983; W. & G. S. West, 1905a, p. 146, pl. 58, f. 10; Borge, 1906, p. 35; Strom, 1926, p. 209, pl. 5, f. 11.

Length 32μ (semicell), breadth 70μ, breadth of isthmus 23μ.

Dist.—Greenland, Faeroes, Scotland, Galicia, Bohemia, Italy, Norway, Sweden, Bornholm, Poland, Spitzbergen, Nova Zembla.

New to Asia.

This is one of the rarest species of Desmids in the Northern Kurile districts and I could only examine a few specimens from the samples of Shumushu Is.

Cosmarium formosulum Hoff. var. *Nathorstii* (Boldt) W. & G. S. West.

(Pl. 27, fig. 10)

C. Nathorstii Boldt. De Toni, 1889, p. 1021; Nordst. 1896, p. 180; W. & G. S. West, 1897a, p. 490; W. & G. S. West, 1898, p. 307.

C. formiosulum Hoff. var. *Nathorstii* (Boldt) W. & G S. West. W. & G. S. West, 1908, p. 242, pl. 88, figs. 4, 5; Allorge, 1924, p. 466; Strom, 1926, p. 210; Homfeld 1929, p. 43, t. 6, f. 60.

Length 47μ, breadth 45μ, breadth of isthmus 16μ.

Dist.—Greenland, United States, Faeroes, England, Germany, Norway.

New to Asia.

Cosmarium galeritum Nordst.

(Pl. 26, fig. 12)

C. galeritum Nordst. Wolle, 1884, p. 70, t. 16, figs. 46, 48; Cooke, 1886, p. 87, t. 42, f. 14; De Toni, 1889, p. 976; W. West, 1892, p. 145; Nordst. 1896, p. 128; W. & G. S. West, 1902a, p. 32; Borge, 1903, p. 95, t. 3, f. 14 (*form*); W. & G. S. West, 1905a, p. 194, pl. 63, figs. 24, 25; Printz, 1915, p. 22; Strom, 1921a, p. 7; Strom, 1926, p. 211; Homfeld, 1929, p. 44, t. 6, f. 61; Allorge, 1931. p. 356, pl. 9, f. 4.

Length 55μ, breadth 40–44μ, breadth of isthmus 18μ.

Dist.—United States, Brazil, Argentina, England, Wales, Scotland, Ireland, Germany, Austria, Spain, Norway, Finmark, W. Africa.

New to Asia.

Cosmarium globosum Bulnh.

(Pl. 26, fig. 9)

C. globosum Bulnh. Nordst. 1873, p. 22; Cooke, 1887, p. 121, t. 43, f. 6; W. West, 1892, p. 160; Nordst. 1896, p. 130; Borge, 1906, p. 36; W. & G. S. West, 1908, p. 29, pl. 68, figs. 1, 2; Dick, 1919, p. 240; Strom, 1922, p. 8; Allorge, 1924, p. 466; Strom, 1926, p. 211; Borge, 1930, p. 33.

Dysphinctium globosum Hansg. De Toni, 1889, p. 880; Himerl, 1891, p. 593.

Length 35μ, breadth 23μ, breadth of isthmus 18μ.

Dist.—C. China (*form*), Greenland, United States, Guiana, Brazil, Argentina, Patagonia, England, Wales, Scotland, Ireland, France, Germany, Norway, Sweden, Denmark, Finland, N. Russia, Nova Zembla, Spitzbergen, E. Africa.

New to Japan.

Cosmarium granatum Bréb.

(Pl. 27, fig. 17)

C. granatum Bréb. Ralfs, 1848, p. 96, t. 32. f. 6; Nordst. 1873, p. 19; Klebs, 1879, p. 32; Wolle, 1884, p. 60, t. 50. f. 13; Cooke, 1886, p. 83, t. 36, f. 9; Nordst. 1888, p. 198; De Toni, 1889, p. 931; Heimerl, 1891, p. 596; W. West, 1892, p. 143; W. & G. S. West, 1895, p. 54; Nordst. 1896, p. 133; W. & G. S. West, 1897a, p. 485; W. & G. S. West, 1897b, p. 113; Borge, 1901, p. 24; W. & G. West, 1902a, p. 32; W. & G. S. West, 1902b, p. 162; W. & G. S. West, 1903, p. 526; Cushman, 1903b, p. 514; Borge, 1903, p. 95; W. & G. S. West, 1905b, p. 484; W. & G. S. West, 1905a, p. 186, pl. 63, figs. 1–3; Borge, 1906, p. 37; G. S. West, 1907, p. 117; Bernard, 1908, p. 104, f. 150; Printz, 1915, p. 22; Dick, 1919, p. 242; Strom, 1921a, p. 4; Borge, 1921, p. 17, t. 1, f. 9; Smith, 1924, p. 31, pl. 57, f. 18; Allorge, 1924, p. 466; Donat, 1926, p. 15; Strom, 1926, p. 211; Lowe, 1927, p. 310; Borge, 1928, p. 101; Deflandere, 1928, p. 234, figs. 142, 143 (*form*); Borge, 1928, p. 101; Homfeld, 1929, p. 44, t. 6, f. 62; Borge, 1930, p. 33; Allorge, 1931, p. 356, pl. 8, f. 11; Borge, 1933, p. 14.

Length 35μ, breadth 20μ, breadth of isthmus 6μ.

Dist.—Siberia, India, Ceylon, Burma, Java, W., N. & C. China, Afghanistan, Australia, New Zealand, Greenland, Canada, United States, West Indies, Brazil, Argentina, Patagonia, Faeroes, Iceland, England,

Wales, Scotland, France, Germany, Austria, Galicia, Poland, Hungary, Italy, Bosnia, Portugal, Norway, Sweden, Spain, Denmark, Bornholm, Finland, N. & S. Russia, Spitzbergen, Nova Zembla, Kordofan, Africa.

New to Japan.

Cosmarium Hammeri Reinsch var. *protuberans* W. & G. S. West.

(Pl. 26, fig. 2)

C. Hammeri Reinsch var. *protuberans* W. & G. S. West. W. & G. S. West, 1896, p. 246, t. 14, f. 35; W. & G. S. West, 1905a, p. 183, pl. 62, figs. 24, 25.

Length 25μ, breadth 20–21μ, breadth of isthmus 7.5μ.

Dist.—United States, Scotland.

New to Asia.

Cosmarium Holmiense Lund. var. *integrum* Lund.

(Pl. 26, fig. 5)

C. Holmiense Lund. var. *integrum* Lund. Borge, 1892, p. 57, t. 1, f. 10; Nordst. 1896, p. 140; W. & G. S. West, 1898, p. 300; W. & G. S. West, 1902a, p. 32; Borge, 1906, p. 35; W. & G. S. West, 1908, p. 2, pl. 65, figs. 3–5; Strom, 1926, p. 211; Homfeld, 1929, p. 44, t. 6, f. 63.

Length 40μ, breadth 23–25μ, breadth of apex 18–20μ, breadth of isthmus 13μ.

Dist.—United States, Faeroes, England, Wales, Scotland, Ireland, Austria, Galicia, Germany, Switzerland, Norway, Sweden, Spitzbergen, Nova Zembla.

New to Asia.

Cosmarium impressulum Elfv.

(Pl. 26, fig. 6)

C. Meneghinii Bréb. var. *simplicissimum* Wille. De Toni, 1889, p. 938; W. & G. S. West, 1897b, p. 37.

C. impressulum Elfv. Roy & Biss. 1886, p. 195, t. 268, f. 10; De Toni, 1889, p. 840; Heimerl, 1891, p. 599; W. West, 1892, p. 147; Nordst. 1896, p. 143; W. & G. S. West, 1897a, p. 487; W. & G. S. West, 1902a, p. 35; W. & G. S. West, 1905b, p. 484; W. & G. S. West, 1908, p. 86, pl. 72, figs. 14–18; Printz, 1915, p. 26; Strom, 1921a, pp. 7, 8; Strom, 1921b, p. 16; Borge, 1921, p. 18; Strom, 1922, p. 8; Allorge, 1924, p. 466; Donat, 1926, p. 15; Strom, 1926, p. 212; Lowe, 1927, p. 310; Homfeld, 1929, p. 45; Borge, 1930, p. 36; Allorge, 1931, p. 357.

C. Meneghinii Bréb. forma *Reinschii* Istvanffi. Borge,1894, p. 27, t. 2, f. 26; Borge, 1896, p. 24; Borge, 1903, p. 98.

Length 22μ, breadth 16–17μ, breadth of isthmus 6μ.

Dist.—Japan, Siberia, India, Australia, New Zealand, Greenland, Canada, United States, Brazil, Argentina, Patagonia, Faeroes, England, Wales, Scotland, Ireland, France, Germany, Sweden, Spain, Switzerland, Bohemia, Austria, Denmark, Finland, Bosnia, Azores, W. & E. Africa.

Cosmarium margaritiferum Menegh.

(Pl. 26, fig. 11)

C. margaritiferum Menegh. Hass. 1845, p. 362, t. 81, f. 1; Ralfs. 1848, p. 100, t. 16, 2d; De Dary, 1858, pp. 47, 72; De-Notaris, 1867, p. 44; Nordst. 1873, p. 11; Cooke, 1887, p. 102, t. 39, f. 2; De Toni, 1889, p. 979; Himerl, 1891, p. 595; W. West, 1892, p. 152; Nordst. 1896, p. 165; W. & G. S. West, 1897a, p. 488; W. & G. S. West, 1902a, p. 37; W. & G. S. West, 1905b, p. 484; Borge, 1906, p. 31; W. & G. S. West, 1908, p. 199, pl. 83, figs. 4–11; Printz, 1915, p. 29; Grönblad, 1920, p. 43; Borge, 1921, p. 15; Strom, 1922, p. 9; Allorge, 1924, p. 466; Donat, 1926, p. 17; Strom, 1926, p. 213; Deflandre, 1928, p. 235; Homfeld, 1929, p. 46; Borge, 1930, p. 30; Allorge, 1931, p. 357, pl. 9, f. 7.

C. Malinvernianum (Racib.) Schmid. var. *Badense* Schmid. W. & G. S. West, 1902a, p. 40; W. & G. S. West, 1903, p. 527.

Length 57μ, breadth 52–55μ, breadth of isthmus 16μ.

Dist.—Siberia, Java (*form*), New Zealand, Greenland, United States, Mexico, Brazil, Faeroes, Iceland, England, Wales, Scotland, Ireland, France, Germany, Belgium, Switzerland, Austria, Poland, Hungary, Italy, Norway, Sweden, Spain, Bornholm, Denmark, Finland, Russia, Bosnia, Azores.

New to Japan.

Cosmarium nasutum Nordst. forma *granulata* Nordst.

(Pl. 27, fig. 4)

C. nasutum Nordst. forma *granulata* Nordst. W. & G. S. West, 1908, p. 260, pl. 90, figs. 11, 12.

Length 38μ, breadth 32μ, breadth of isthmus 12μ.

Dist.—Greenland, England, Wales, Scotland, Austria, Bornholm, Finland, Spitzbergen, Nova Zembla.

New to Asia.

This alpine and arctic Desmids is one of the rarest species in the Northern Kuriles and I could only observed from the sample collected at the foot of Mt. Shiriyajiri, about 400 m. above the sea-level.

Cosmarium Nymannianum Grun.

(Pl. 27, fig 11)

C. Nymannianum Grun. Nordst. 1873, p. 17; Wolle, 1884, p. 79; Cooke, 1886, p. 82, t. 36, f. 1; De Toni, 1889, p. 964; W. West, 1892, p. 142; Nordst. 1896, p. 184; W. & G. S. West, 1897a, p. 485; W. & G. S. West, 1902a, p. 32; W. & G. S. West, 1902b, p. 161; W. & G. S. West, 1905a, p. 184, pl. 62, figs. 26, 27; Grönblad, 1920, p. 44; Donat, 1926, p. 15; Strom. 1926, p. 215; Homfeld, 1929, p. 47; Borge, 1930, p. 34, t. 2, f. 26; Allorge, 1931, p. 357.

Length 42μ, breadth 32μ, breadth of apex 15μ, breadth of isthmus 11μ.

Dist.—Ceylon, United States, Foeroes, England, Wales, Scotland, Ireland, France, Germany, Galicia in Austria, Norway, Sweden, Spain, Denmark, Poland, Finland, S. Russia.

New to Japan.

Cosmarium ochthodes Nordst.

(Pl. 27, fig. 5)

C. ochthodes Nordst. Cooke, 1887, p. 109, t. 41, f. 3; Nordst. 1888, p. 192; De Toni. 1889, p. 992; Nordst. 1896, p. 187; W. & G. S. West, 1897a, p. 490; W. & G. S. 1902a, p. 40; Borge, 1906, p. 30; W. & G. S. West, 1911, p. 10, pl. 98, figs. 1–3; Printz, 1915, p. 30; Grönblad, 1920, p. 44; Borge, 1921, p. 15; Donat, 1926, p. 17; Strom, 1926, p. 215; Homfeld, 1929, p. 48; Allorge, 1931, p. 358.

Length 79μ, breadth 60–61μ, breadth of isthmus 27μ.

Dist.—Greenland, United States, Faeroes, England, Wales, Scotland, Ireland, France, Germany, Austria, Galicia, Bosnia, Roumania, Italy, Norway, Sweden, Spain, Bornholm, Finland, Russian Lapland, N. Russia, Nova Zembla, Spitzbergen.

New to Asia.

Cosmarium Portianum Arch.

(Pl. 27, fig. 2)

C. orbiculatum De Bary. De Bary, 1858, p. 41, t. 6, figs. 49, 50; Delp. 1877, p. 11, t. 7, figs. 56–48.

C. Portianum Arch. Nordst. 1873, p. 22; Wolle, 1884, p. 77, t. 14, figs. 12, 13; Lagerheim, 1885, p. 235; Cooke, 1887, p. 103, t. 39, f. 3; De Toni, 1889, p. 986; W. West, 1892, p. 152; Nordst. 1896, p. 204; W. & G. S. West, 1897a, p. 488; W. & G. S. West, 1902a, p. 38; Borge, 1906, p. 31; W. & G. S. West, 1908, p. 165, pl. 80, figs. 4–7; Bernard, 1908, p. 110, figs. 168–170; Printz, 1915, p. 28; Dick, 1919, p. 244; Grönblad, 1920, p. 46; Smith, 1924, p. 33, pl. 57, f, 24; Donat, 1926, p. 18; Strom, 1926, p. 216; Lowe, 1927, p. 310; Borge, 1930, p. 30; Allorge, 1931, p. 358, pl. 10, f. 35; Borge, 1933, p. 14 (*form*).

Length 34μ, breadth 20μ, breadth of isthmus 8μ.

Dist.—Japan, Siberia, C. China, India, Ceylon, Australia, Canada, United States, Brazil, England, Wales, Scotland, Ireland, France, Germany, Belgium, Austria, Galicia, Poland, Italy, Norway, Sweden, Spain, Bornholm, Finland, N. Russia, Spitzbergen, Nova Zambla, Azores.

Cosmarium Portianum Arch. var. *nephroideum* Wittr.

(Pl. 27, fig. 1)

C. Portianum Arch. var. *nephroideum* Wittr. Nordst. 1888, p. 193, t. 6, f. 15; Himerl, 1891, p. 596; W. West, 1892, p. 153; W. & G. S. West, 1902a, p. 38; W. & G. S. West, 1908, p. 167, pl. 80, figs. 10, 11; Dick, 1919, p 244; Strom, 1926, p. 216; Allorge, 1931, p. 358.

C. armillatum Turner. Turner, 1893, p. 55, t. 8, f. 22.

Length 21μ, bread 17—18μ, breadth of isthmus 7μ.

Dist.—C. China, Faeroes, Iceland, Scotland, Ireland, France, Germany, Austria, Galicia, Norway, Sweden, Spain.

New to Japan.

Cosmarium punctulatum Bréb. var. *subpunctulatum* (Nordst.) Börg. (*small form*)

(Pl. 27, fig. 9)

C. subpunctulatum Nordst. De Toni, 1889, p. 1049; Borge, 1891, p. 11; W. West, 1892, p. 154; Nordst. 1896, p. 246; W. & G. S. West, 1897a. p. 488; W. & G. S. West, 1902a, p. 38; Borge, 1906, p. 32.

C. punctulatum Bréb. var. *subpunctulatum* (Nordst.) Börg. Borge, 1901, p. 21; W. & G. S. West, 1908, p. 209, pl. 84, figs. 15–20; Printz, 1915, p. 29; Strom, 1921a, p. 4; Grönblad, 1920, p. 47; Borge, 1921, p. 15; Allorge, 1924, p. 466; Smith, 1924, p. 37, pl. 57, f. 29; Donat, 1926, p. 18; Strom, 1926, p. 218; Homfeld, 1929, p. 51; Borge, 1930, p. 30; Allorge, 1931, p 359; Skvortz. 1932, p. 151, pl. 3, f. 43.

Length 23μ, breadth 20–22μ, isthmus 10μ.

Dist—Korea, Siberia, Australia, New Zealand, United States, Brazil, Patagonia (*form*), Faeroes, England, Wales, Scotland, Ireland, Germany, Austria (*form*), Silesia, Switzerland, Norway, Sweden, Spain, Bornholm, Finland, N. Russia, Bosnia.

Cosmarium quadratum Ralfs.

(Pl 27, fig. 14)

C. quadratum Ralfs. Ralfs, 1848, p. 92, t. 15, f. 1a; Nordst. 1873, p. 23; Wolle, 1884, p. 59, t. 18, f. 10; Cooke, 1886, p. 80, t. 36, f. 2; Nordst. 1888, p. 198; Heimerl, 1891, p. 596; W. West, 1892, p. 142; Nordst. 1896, p. 217; W. & G. S. West, 1897a, p. 485; Borge, 1901, p. 23; W. & G. S. West, 1902a, p. 32; Borge, 1906, p. 36; W. & G. S. West, 1908, p. 57, pl. 70, figs. 6–8; Printz, 1915, p. 25; Homfeld, 1929, p. 52, pl. 7, f. 72; Donat, 1926, p. 16; Strom, 1926, p. 218; Homfeld, 1929, p. 52, t. 7, f. 72; Borge, 1930, p. 32; Allorge, 1931, p. 360.

Dysphinctium quadratum (Ralfs) Hansg. De Toni, 1889, p. 882.

Length 62μ, breadth 36–37μ, breadth of isthmus 27μ.

Dist.—Siberia, New Zealand (*form*), Greenland, United States, W. Indies, Patagonia (*form*), Faeroes, Iceland, England, Wales, Scotland, Ireland, France, Germany, Austria, Galicia, Norway, Sweden, Spain, Denmark, Bornholm, Finland, Russian Lapland, N. & S. Russia, Nova Zembla, Spitzbergen.

New to Japan.

Cosmarium quadrifarium Lund. forma *hexasticha* (Lund.) Nordst.

(Pl. 27, figs. 6, 6′)

C. hexastichum Lund. Cooke, 1887, p. 115, t. 40, f. 9; De Toni, 1889, p. 1023.

C. quadrifarium Lund. forma *hexasticha* (Lund.) Nordst. W. West, 1892, p. 158; Borge, 1903, p. 100, t, 3, f. 30 (*form*); W. & G. S. West, 1908, p. 143, pl. 77, f. 4; Grönblad, 1920, p. 47; Homfeld, 1929, p. 52; Borge, 1930, p. 38.

Length 48μ, breadth 35–37μ, breadth of isthmus 18μ, thickness 26μ.

Dist.—Siam, Australia, New Zealand, Greenland, Brazil (*form*), England, Wales, Ireland, Germany, Norway, Sweden, Finland.

New to Japan.

Cosmarium reniforme (Ralfs) Arch.

(Pl. 27, fig. 7)

C. margaritiferum Menegh. var. *reniformis* Ralfs. Ralfs, 1848, p. 100, t. 16, f. 2a.

C. margarititiferum Menegh. forma *genuina* Nordst. Nordst. 1873, p. 11.

C. reniforme (Ralfs) Arch. Wolle, 1884, p. 76, t. 14, figs. 10, 11; Cooke, 1887, p. 104, t. 42, f. 10; Nordst. 1888, p. 192; De Toni, 1889, p. 982; W. West, 1892, p. 153; Nordst. 1896, p. 223; W. & G. S. West, 1897a, p. 488; W. & G. S. West, 1898, p. 307,

t. 17, f. 9; W. & G. S. West, 1902a, p. 37; W. & G. S. West, 1903, p. 527; Borge, 1903, p. 87; W. & G. S. West, 1905, p. 485; Borge, 1906a, p. 8; Borge, 1906, p. 31; W. & G. S. West, 1908, p. 157, pl. 79, figs. 1, 2, pl, 82, f. 15; Printz, 1915, p. 28; Strom, 1921a, p. 7; Borge, 1921, p. 15; Allorge, 1924, p. 466; Smith, 1924, p. 33, pl. 57, f. 23; Donat, 1926, p. 18; Lowe, 1927, p. 310; Homfeld, 1929, p. 54; Borge, 1930, p. 30; Allorge, 1931, p. 360, pl. 11, f. 1.

Length 55μ, breadth 46–48μ, breadth of isthmus 18μ.

Dist.—Greenland, Canada, United States, Brazil, Argentina, Faeroes, England, Wales, Scotland, Ireland, France, Germany, Switzerland, Austria, Galicia, Italy, Norway, Finmark, Sweden, Spain, Spitzbergen.

New to Asia.

Cosmarium subcrenatum Hantzsch. (*form*)

(Pl. 27, fig. 3)

C. suberenatum Hantzsch. Nordst. 1888, p. 196; De Toni, 1889, p. 1000; W. West, 1892, p. 150; Nordst. 1896, p. 244; W. & G. S. West, 1897a, p. 488; W. & G. S. West, 1902a, p. 37; Borge, 1906, p. 34; W. & G. S. West, 1908, p. 228, pl. 86, figs. 10–14; Pintz, 1915, p. 30; Dick, 1919, p. 246; Strom, 1921a. p. 7; Borge, 1921, p. 16; Strom, 1921b, p. 16; Strom, 1922, p. 10; Strom, 1926, p. 221; Lowe, 1927, p. 311; Homfeld, 1929, p. 56; Borge, 1930, p. 31; Allorge, 1931, p. 360.

Length 35μ, breadth 30μ, breadth of isthmus 10μ.

Dist.—Siberia, Manchuria, Sumatra, Greenland, Canada, United States, Ecuador, Uruguay, Patagonia, Faeroes, Iceland, England, Wales, Scotland, Ireland, France, Germany, Galicia in Austria, Italy, Spain, Norway, Sweden, Bornholm, Finland, Poland, N. Russia, Nova Zembla, Franz Joseph Land, Spitzbergen, E. & C. Africa.

New to Japan.

Cosmarium tetraophthalmum Bréb.

(Pl. 26, fig. 1)

C. tetraophthalmum Bréb. Ralfs, 1848, p. 98, t. 17, f. 11, t. 33, f. 8; De Bary, 1858, p. 54; De-Notaris, 1867, p. 38; Delp. 1877, p. 26, t. 9, figs. 1–4; Cooke, 1887, p. 99, t. 38, f. 1; De Toni, 1889, p. 981; W. West, 1892, p. 151; Nordst. 1896, p. 253; W. & G. S. West, 1897a, p. 488; W. & G. S. West, 1902a, p. 37; Cushman, 1903a, p. 223; W. & G. S. West, 1905, p. 485; Borge, 1906, p. 30; W. & G. S. West, 1908, p. 270, pl. 95, figs. 4–7; Printz, 1915, p. 30; Dick, 1919, p. 244; Grönblad, 1920, p. 50; Borge, 1921, p. 15; Strom, 1926, p. 223; Lowe, 1927, p. 311; Guerrero, 1927, p. 15; Homfeld, 1929, p. 58; Borge, 1930, p. 29; Allorge, 1931, p. 361.

C. tetraophthalmum Bréb. var. *Lundellii* Wittr. Nordst. 1873, p. 12; W. West, 1892, p. 152; W. & G. S. West, 1897a, p. 488; Borge, 1906, p. 30.

Length 115μ, breadth 86μ, breadth of isthmus 32μ.

Dist.—Japan, Mongolia, China, India, New Zealand, Canada, United States, Brazil, Patagonia, Greenland, Faeroes, Iceland, England, Wales, Scotland, Ireland, France, Belgium, Germany, Austria, Galicia, Bosnia, Hungary, Italy, Switzerland, Norway, Sweden, Spain, Bornholm, Poland, Finland, Russian Lapland, N. Russia, Spitzbergen.

Cosmarium Turpinii Bréb. var. *podolicum* Gutw. (*form*)

(Pl. 27, fig. 16)

C. Turpinii Bréb. var. *podolicum* Gutw. W. & G. S. West, 1908, p. 191, pl. 83, f. 2; Homfeld, 1929, p. 60.

Length 80μ, breadth 72μ, breadth of isthmus 27μ.

Dist.—United States, Ireland, Germany, Galicia in Austria.

New to Asia.

Cosmarium undulatum Corda.

(Pl. 27, fig. 12)

C. undulatum Corda. Ralfs, 1848, p. 97, t. 15, f. 8; Nordst. 1873, p. 1872, p. 15; Wolle, 1884, p. 67, t. 16, figs. 20, 21; Cooke, 1886, p. 97, t. 37, f. 16; Nordst. 1888, p. 196; W. West, 1892, p. 151; Nordst. 1896, p. 265; W. & G. S. West, 1897a, p. 488; W. & G. S. West, 1905, p. 148, pl. 59, figs. 1–3, 5; Borge, 1906, p. 35; Printz, 1915, p. 19; Grönblad, 1920, p. 50; Donat, 1926, p. 17; Strom, 1926, p. 223; Homfeld, 1929, p. 60; Allorge, 1931, p. 361.

Length 52μ, breadth 38μ, breadth of isthmus 15μ.

Dist.—New Zealand, Greenland, United States, England, Wales, Scotland, Ireland, France, Germany, Austria, Galicia, Bohemia, Hungary, Italy, Norway, Sweden, Denmark, Spain, Bornholm, Finland, Lapland, S. Russia, Spitzbergen, Afghanistan, Abyssinia.

New to Asia.

Cosmarium venustum (Bréb.) Arch.

(Pl. 26, fig. 3)

Euastrum venustum Bréb. Cooke, 1886, p. 77, t. 35, f. 11.

Cosmarium venustum (Bréb.) Arch. De Toni, 1889, p. 946; W. West, 1892, p. 147; Nordst. 1896, p. 268; W. & G. S. West, 1897a, p. 487; W. & G. S. West, 1902a, p. 35; Borge, 1903, p. 98 (*form*); Borge, 1906, p. 39; W. & G. S. West, 1908, p. 8, pl. 66, figs. 1–3; Printz, 1915, p. 23; Grönblad, 1920, p. 50; Strom, 1932, p. 10; Donat, 1926, p. 17; Strom, 1926, p. 224; Borge, 1930, p. 35 (*from*); Allorge, 1931, p. 361.

C. Cambricum Cook. & Wills. Cooke, 1887, p. 98, t. 42, f. 16; De Toni, 1889, p. 957.

Length 42μ, breadth 28–30μ, breadth of isthmus 9μ.

Dist.—Siberia, India, Sumatra (*form*), Java, Australia, Greenland, United States, Paraguay, Faeroes, England, Wales, Scotland, Ireland, France, Germany, Austria, Galicia, Norway, Sweden, Denmark, Spain, Finland, Poland, Russian Lapland, S. Russia, Nova Zembla, Azores.

New to Japan.

Gen. **Xanthidium** Ehrenb. 1837.

Xanthidium antilopaeum (Bréb.) Kütz.

(Pl. 28, fig. 1)

X. fasciculatum Ehrenb. Ralfs, 1848, p. 114, t. 20, f. 1; De Not. 1867, t. 4, f. 36; Delp. 1873, p. 168, t. 13, figs. 20–22; Wolle, 1884, p. 93, t. 22, figs. 4, 5.

X. antilopaeum (Bréb.) Kütz. Nordst. 1873, p. 38; Wolle, 1884, p. 94, t. 23, figs. 1, 2; Cooke, 1887, p. 132, t. 46, f. 2; Nordst. 1888, p. 207; De Toni, 1889, p. 920; Himerl, 1891, p. 595; W. West, 1892, p. 165; W. & G. S. West, 1897a, p. 484; W. & G. S. West, 1902a, p. 31; W. & G. S. West, 1903, p. 527; Borge, 1903, p. 104; W. & G. S. West, 1905b, p. 72; Borge, 1906, p. 28; W. & G. S. West, 1911, p. 63, pl. 108, figs. 7–18; Printz, 1915, p. 32; Strom, 1921a, p. 8; Strom, 1921b, p. 16; Grönblad, 1921, p. 44, pl. 4, figs. 1–4; Smith, 1924, p. 57, pl. 65, figs. 5, 6; Donat, 1926, p. 18; Deflandre, 1928, p. 235, f. 155; Strom, 1926, p. 224; Lowe, 1927, p. 311; Homfeld, 1929, p. 62; Borge, 1930, p. 41, t. 2, figs. 33–35; Allorge, 1931, p. 361.

X. spinulosum Benn. Cooke, 1886, p. 132, t. 46, f. 4; De Toni, 1889, p. 928.

Length, without spines, 60μ; with spines, 80–82; breadth, without spines, 58μ; with spines, 85μ; breadth of isthmus 22μ.

Dist.—Japan, Siberia, Mongolia, N. India, Canada, United States, Brazil, Paraguay, Faeaoes, England, Wales, Scotland, Ireland, France, Germany, Austria, Galicia, Roumania, Norway, Sweden, Bornholm, Finland, N. Russia.

Xanthidium antilopaeum (Bréb.) Kütz. var. *polymazum* Nordst.

(Pl. 28, fig. 5)

X. antilopaeum (Bréb.) Kütz. var. *polymazum* Nordst. Nordst. 1873, p. 38 t. 1, f. 8; Wolle, 1884, p. 94, t. 23, figs. 3, 4; W. & G. S. West, 1905, p. 485; Borge, 1906, p. 29; W. & G. S. West, 1911, p. 67, pl. 108, f. 19; Grönblad, 1920, p. 51; Strom, 1921b, p. 16; Lowe, 1927, p. 311; Homfeld, 1929, p. 63; Borge, 1930, p. 42.

Length, without spines, 54μ; with spines, 82–85μ; breadth, without spines, 56μ; with spines, 90–92μ; breadth of isthmus 19μ.

Dist.—Canada, United States, Scotland, Norway, Sweden, Finland, Germany, Bornholm.

New to Asia.

Xanthidium antilopaeum (Bréb.) Kütz. var. *triquetrum* Lund.

(Pl. 28, fig. 9)

X. antilopaeum (Bréb.) Kütz. var. *triquetrum* Lund. Nordst. 1873, p. 38; Wolle, 1884, p. 94, t. 22, figs. 1–3; De Toni, 1889, p. 921; W. & G. S. West, 1911, p. 66, pl. 109, f. 1; Borge, 1906, p. 29; Grönblad, 1920, p. 51; Strom, 1921a, p. 8; Grönblad, 1921, p. 45, pl. 4, f. 8; Strom, 1926, p. 224; Borge, 1930, p. 42.

Length, without spines, 78; with spines, 98μ; breadth, without spines, 68–70μ; with spines, 96–100μ; breadth of isthmus 30μ.

Dist.—Brazil (*forma*), England, Sweden, Norway, Finland, Austria, Galicia.

New to Asia.

Xanthidium armatum (Bréb.) Rabenh.

(Pl. 28, figs. 12, 12′, 12″)

X. armatum (Bréb.) Rabenh. Ralfs, 1848, p. 112, t. 18; De-Notaris, 1867, p. 47; Nordst. 1873, p. 37; Wolle, 1884, p. 92, t. 21, figs. 2–4; Lagerh. 1885, p. 245; Cook. 1887, p. 129, t. 45, f. 1; De Toni, 1889, p. 916; Himerl, 1891, p. 595; W. West, 1892, p. 164; Nordst. 1896, p. 51; W. & G. S. West, 1897a, p. 484; Borge, 1901, p. 229; W. & G. S. West, 1902a, p. 30; W. & G. S. West, 1903, p. 527; Cushm. 1903a, p. 583, t, 26, f. 7; W. & G. S. West, 1905, p. 485; W. & G. S. West, 1906, p. 85; Borge, 1906, p. 28; W. & G. S. West, 1909, p. 138; W. & G. S. West, 1911, p. 51, pl. 104, figs. 1–5; Printz, 1915, p. 32; Grönblad, 1920, p. 52; Smith, 1924, p. 56; Donat, 1926, p 19; Strom, 1926, p. 225; Homfeld, 1929, p. 64; Borge, 1930, p. 41; Allorge, 1931, p. 362, pl. 11, figs. 3–5.

Length, without spines, 116–119μ; with spines, 132–135μ; breadth, without spines, 76μ; with spines, 96μ; breadth of isthmus 36μ; thickness 58μ.

Dist.—Japan, N. India, United States, Cuba, Faeroes, England, Wales, Scotland, Ireland, France, Germany, Austria, Galicia, Hungary, Italy, Norway, Sweden, Denmark, Spain, Finland, Poland, N. & S. Russia.

Xanthidium armatum (Bréb.) Rabenh. var. *fissum* Nordst.

(Pl. 28, fig. 4)

X. armatum (Bréb.) Rabenh. var. *fissum* Nordst. Nordst. 1878, p. 17, t. 2, f. 6; W. & G. S. West, 1911, p. 54, pl. 105, figs. 1, 2; Strom, 1926, p. 225.

Length, without spines, 110μ; with spines, 140μ; breadth, without spines, 85μ; with spines, 110–122μ; breadth of isthmus 32μ.

Dist.—Sandwich Islands, Wales, Norway.

New to Asia.

Xanthidium cristatum Bréb. var. *leiodermum* (Roy & Biss.) Turner.

(Pl. 28, figs. 6, 10)

X. leiodermum Roy & Biss. Roy & Biss. 1886, p. 240, t. 268, f. 11.

X. glabrum Lagerh. De Toni, 1889, p. 930.

X. cristatum Bréb. var. *leiodermum* (Roy & Biss.) Turn. Turn. 1893, p. 99, t. 12, f. 33; W. & G. S. West, 1911, p. 72, pl. 110, f. 11.

Length, without spines, 43μ; with spines, 60μ; breadth, without spines, 36–38μ; with spines, 52–54μ; breadth of isthumus 15μ.

Dist.—Japan, India, United States, England.

Xanthidium cristatum Bréb. var. *uncinatum* Bréb.

(Pl. 28, fig. 11)

X. cristatum Bréb. var. *uncinatum* Bréb. Ralfs, 1848, p. 115, t. 19, f. 3d–f; Cook., 1887, p. 133; De Toni, 1889, p. 923; W. West, 1892, p. 165; W. & G. S. West, 1896, p. 253, f. 3; W. & G. S. West, 1911, p. 73, pl. 111, figs. 2–4; Grönblad, 1920, p. 52; Smith, 1924, p. 60, pl. 66, f. 4; Donat, 1926, p. 19; Homfeld, 1929, p. 64.

X. bisenarium (forma *typica*) Turn. Turn. 1893, p. 99, t. 12, f. 30; W. & G. S. West, 1902a, p. 30.

Length, without spines, 72μ; with spines, 95–98μ; breadth, without spines, 50μ; with spines, 75–78μ; breadth of isthmus 17μ.

Dist.—C. China, N. India, United States, England, Scotland, Ireland, France, Germany, Norway, Sweden, Finland.

New to Japan.

Xanthidium triangulare sp. nov.

(Pl. 29, fig. 15, 15′)

Cells of medium size, about $1\frac{3}{5}$ times longer than broad; sinus almost closed, gradually opening outwards; semicells pyramidate, basal angles rounded, sides very slightly convex, apical angles rounded: apical and lateral angles with a pair of simple stright fairly long spines; basal angles furnished with a single stright short spine; in the center of the semicell with a small rounded, brown, thickened area.

Vertical view triangular, with faintly convex sides, each of which slightly thickened in the middle; angles wide and furnished with a pair of shout spines, within each angles with a pair of short shout spines, and between each angle-spines a single short basal spines visible. Cell-wall punctate. Zygospore unknown.

Length, without spines (semicell), 35μ; with spines (semicell), 45μ; breadth, without spines, 40μ; with spines, 65μ; breadth of isthmus 15μ.

Loc.—Hyakuike-ga-hara, Shumushu Is.

Gen. Arthrodesmus Ehrenb. 1838.

Arthrodesmus Bulnheimii Racib.

(Pl. 28, fig. 7)

A. Bulnheimii Racib. Nordst. 1896, p. 70; W. & G. S. West, 1911, p. 105, pl. 116, figs. 1, 2; Printz, 1915, p. 33; Grönblad, 1920, p. 52; Smith, 1924, p. 127, pl. 84, figs. 7, 8; Donat, 1926, p. 19; Homfeld, 1929, p. 66.

Length, without spines, 32μ; with spines, 40μ; breadth, without spines, 27μ; length of spines, 16μ; breadth of isthmus 10μ.

Dist.—United States, Scotland, Germany, Poland, Norway (*form*), Finland.

New to Asia.

Arthrodesmus convergens Ehrenb.

(Pl. 28, figs. 2, 3)

A. convergens Ehrenb. Hass. 1845, p. 357, t. 85, f. 9; Ralfs, 1848, p. 118, t. 20, f. 3; Nordst. 1872, p. 25; Wolle, 1884, p. 95, t. 23, figs. 19–21; Cook, 1887, p. 136, t. 47, f. 1; Nordst., 1888, p. 203; De Toni, 1889, p. 1058; Heimerl, 1891, p. 603; W. West, 1892, p. 169; W. & G. S. West, 1896, p. 254, t. 16, f. 3; Nordst. 1896, p. 81; W. & G. S. West, 1897a, p. 497; G. S. West, 1899, pp. 397, 398 & f. xylogr. 3; W. & G. S.

West, 1902a, p. 58; W. & G. S. West, 1903, p. 528; Borge, 1903, p. 103; W. & G. West, 1905, p. 485; Borge, 1906, p. 49; Bernard, 1908, p. 120, figs. 194, 195; W. & G. S. West, 1911, p. 106, pl. 116, figs. 4–13; Printz, 1915, p. 33; Dick, 1919, p. 251; Grönblad, 1920, p. 52; Allorge, 1924, p. 467; Smith, 1924, p. 126, pl. 84, f. 6; Borge, 1925, p. 37 (*form*); Donat, 1926, p. 19; Woronichin, 1926, p. 219; Guerrero, 1927, p. 16; Lowe, 1927, p. 312; Homfeld, 1929, p. 67; Allorge, 1931, p. 363.

Cosmarium convergens De Bary. De Bary, 1858, p. 72.

Xanthidium convergens Delp. Delp. 1877, p. 76, t. 14, figs. 13–23.

Arthrodesmus convergens Ehrenb. *α typica*, *β. curta*, et *γ minor* Turn. Turn. 1893, p. 134, t. 11, figs. 32, 41, 42; t. 12, f. 3.

Length 40–41μ; breadth, without spines, 42–47μ; with spines, 53–57μ; length of spines 6–15μ; breadth of isthmus 12μ.

Dist.—Japan, C. China, N. India, Caucasus, New Zealand, Greenland, Canada, United States, Brazil, Paraguay, England, Wales, Scotland, Ireland, France, Germany, Austria, Hungary, Italy, Norway, Sweden, Denmark, Spain, Bornholm, Finland, N. & S. Russia, Nova Zembla, Abyssinia, E. & C. Africa.

Arthrodesmus Incus (Bréb.) Hass. var. *indentatus* W. & G. S. West.

(Pl. 29, fig. 2)

Arth. Incus (Bréb.) Hass. var. *indentatus* W. & G. S. West. W. & G. S. West, 1911, p 94, pl. 113, figs. 20–24; Printz, 1915, p. 32; Grönblad, 1920, p. 54; Borge, 1930, p. 41; Allorge, 1931, p. 363.

Length, without spines, 40μ; breadth, without spines, 25μ; length of spines 45–50μ; breadth of isthmus 8.5μ.

Dist.—England, Wales, Scotland, Ireland, Norway, Spain, Finland.

New to Asia.

Arthrodesmus Incus (Bréb) Hass. forma *perforata* Schmidle.

(Pl. 29, fig. 1)

A. Incus (Bréb.) Hass. f. *perporata* Schmidle. W. & G. S. West, 1911, p. 93, pl. 114, f. 1.

Length, without spines, 32μ; with spines, 48μ; breadth, without spines, 26μ; with spines, 53μ; breadth of isthmus 11μ.

Dist.—Wales, Norway.

New to Asia.

Arthrodesmus octocornis Ehrenb.

(Pl. 28, fig. 8)

A. octocornis Ehrenb. Hass. 1845, p. 357, t. 85, f. 11; Nordst. 1873, p. 25; Wolle, 1884, p. 97, t. 24, f. 22; Lagerh. 1885, p. 244; Cook. 1887, p. 134, t. 47, f. 2; De Toni, 1889, p. 1063; W. West, 1892, p. 167; Nordst. 1896, p. 187; W. & G. S. West, 1897a, p. 496, t. 6, f. 16; W. & G. S. West, 1902a, p. 57; W. & G. S. West, 1902b, p. 191; W. & G. S. West, 1903, p. 528; W. & G. S. West, 1905, p. 485; Borge, 1906, p. 49; W. & G. S. West, 1911, p. 111, pl. 117, figs. 6–10; Dick, 1919, p. 251; Strom, 1922, p. 10; Allorge, 1924, p. 467; Smith, 1924, p. 134, pl. 86, figs. 8–12; Donat, 1926, p. 19; Strom, 1928, p. 226; Woronichin, 1926, p. 219; Homfeld, 1929, p. 68; Borge, 1930, p. 40; Allorge, 1931, p. 363.

Length, without spines, 25μ; with spines, 40μ; breadth, without spines, 18–19μ; with spines, 36μ; breadth of isthmus 7μ.

Dist.—Japan, Mongolia, Burma, Ceylon, Caucasus, Australia, Greenland, United States, Cuba, Faeroes, Iceland, England, Wales, Scotland, Ireland, France, Germany, Poland, Austria, Galicia, Italy, Norway, Sweden, Spain, Poland, Denmark, Bornholm, Finland, N. Russia.

Arthrodesmus quiriferus W. & G. S. West var. *brevispinis* *var. nov.*

(Pl. 29, fig. 3)

Cells small, a little longer than broad (without spines), fairly deeply constricted, sinus not quite widely open as in the type and submamillate at the extremity; semicells obversely subtrapeziform–triangular, apex widely concave and each angle furnished with a short straight spine.

Vertical view elliptic, with a strong short spine at each pole. Zygospore unknown.

Length, without spines, 17μ; with spines, 22–25μ; breadth, without spines, 15μ, with spines, 20μ; breadth of isthmus 7μ.

Loc.—Shiginosu-daira, Paramushiro Is.

Gen. **Staurastrum** Meyen, 1829; em. Ralfs.

Staurastrum aculeatum (Ehr.) Menegh.

(Pl. 29, figs. 14, 14′)

St. aculeatum (Ehr.) Menegh. Ralfs. 1848, p. 142, t. 23, f. 2; Nordst. 1873, p. 33; Delp. 1873, p. 63, t. 13, figs. 3–5; Wolle, 1884, p. 140, t. 45, figs. 1–3; Cook. 1887, p. 174, t. 60, f. 2; De Toni, 1889, p. 1216; W. & G. S. West, 1897a, p. 496; G. S. West,

1899, p. 393, t. 11, figs. 28–32; Borge, 1906, p. 48; W. & G. S. West, 1909, p. 203; Printz, 1915, p. 36; Dick, 1919, p. 256; Grönblad, 1920, p. 55; W. & G. S. West, 1923, p. 160, pl. 160, figs. 1–4; Donat, 1926, p. 21; Strom, 1926, p. 227; Homfeld, 1929, p. 68; Borge, 1930, p. 48; Allorge, 1931, p. 363, pl. 14, figs. 1, 2.

Length 47μ; breadth, including spines, 60–62μ; breadth of isthmus 18μ.

Dist.—Japan, Siberia, Burma, Australia, New Zealand, Greenland, United States, Patagonia, England, Wales, Scotland, Ireland, France, Germany, Switzerland, Galicia, Austria, Hungary, Servia, Italy, Norway, Sweden, Denmark, Spain, Finland, N. Russia, Nova Zembla.

Staurastrum alternans Bréb.

(Pl. 29, fig. 8)

St. alternans Bréb. Ralfs, 1848, p. 132, t. 21, f. 7; Nordst. 1873, p. 29; Delp. 1873, p. 47, t. 11, figs. 39–42; Cook. 1887, p. 162, t. 54, f. 7; De Toni, 1889, p. 1193; W. West, 1892, p. 180; Nordst. 1896, p. 41; W. & G. S. West, 1897a, p. 494; W. & G. S. West, 1902a, p. 51; Borge, 1906, p. 46; G. S. West, 1907, p. 125; G. S. West, 1909, p. 28; W. & G. S. West, 1911, p. 170, pl. 126, figs. 8, 9; G. S. West, 1911, p. 88; Printz, 1915, p. 35; Borge, 1921, p. 22; Smith, 1924, p. 70, pl. 68, f. 4; Donat, 1926, p. 19; Strom, 1926, p. 227; Woronichin, 1926, p. 220; Guerrero, 1927, p. 17; Lowe, 1927, p. 312; Homfeld, 1929, p. 68; Borge, 1930, p. 45; Allorge, 1931, p. 363, pl. 12, figs. 14, 15; Skvortz. 1932, p. 154, pl. 5, f. 63.

Length 35μ, breadth 32–37μ, breadth of isthmus 10μ.

Dist.—Korea, India, Siam, Caucasus, Australia, New Zealand, Greenland, Canada, United States, Faeroes, Iceland, England, Wales, Scotland, Ireland, France, Germany, Austria, Galicia, Servia, Italy, Norway, Sweden, Spain, Denmark, Bornholm, Finland, N. Russia, Nova Zembla, C. Africa.

Staurastrum apiculatum Bréb.

(Pl. 30, fig. 7)

St. apiculatum Bréb. Cook. 1887, p. 139, t. 49, f. 2; Borge, 1894, p. 37; W. & G. S. West, 1896, p. 254, t. 16, f. 6; W. & G. S. West, 1901, p. 92; W. & G. S. West, 1902a, p. 44; W. & G. S. West, 1923, p. 6, pl. 129, figs. 6–8; Borge, 1925, p. 38; Donat, 1926, p. 19; Homfeld, 1926, p. 68; Woronichin, 1926, p. 219; Borge, 1930, p. 44; Allorge, 1931, p. 363.

Length 15μ, breadth 15μ, breadth of isthmus 8μ, length of spines 6μ.

Dist.—Japan, Burma, Siam, Caucasus, Australia, W. Greenland, United States, Brazil, England, Wales, Scotland, Ireland, France, Germany, Galicia in Austria, Turkey, Norway, Sweden, Denmark, Spain, Finland, N. Russia.

Staurastrum brachiatum Ralfs.

(Pl. 30, fig. 11)

St. brachiatum Ralfs. Ralfs, 1845, p. 131, t. 23, f. 9; De-Not. 1867, p. 54, t. 5, f. 50; Nordst. 1873, p. 28; Wolle, 1884, p. 124, t. 40, figs. 37–39; Cook. 1887, p. 167, t. 58, f. 1; De Toni, 1889, p. 1202; Himerl, 1891, p. 606; W. & G. S. West, 1896, p. 262, t. 16, f. 32; W. & G. S. West, 1897a, p. 494; G. S. West, 1899, p. 391, t. 11, figs. 5–15; W. & G. S. West, 1902a, p. 49; Borge, 1906, p. 45; Grönblad, 1920, p. 58; W. & G. S. West, 1923, p. 88, pl. 141, figs. 14, 15, pl. 142, figs. 1–7; Smith, 1924, p. 82, pl. 72, figs. 1–4; Strom, 1926, p. 229, pl. 6, f. 4; Lowe, 1927, p. 313; Homfeld, 1929, p. 70, t. 8, f. 92; Borge, 1930, p. 45; Allorge, 1931, p. 364, pl. 13, figs. 4, 5.

Length 32μ, breadth 30–32μ, breadth of isthmus 10μ.

Dist.—Japan, Australia, Greenland, Canada, United States, Colombia, Faeroes, England, Wales, Scotland, Ireland, France, Belgium, Germany, Switzerland, Galicia in Austria, Hungary, Italy, Norway, Sweden, Denmark, Spain, Finland, Azores.

Staurastrum cuspidatum Bréb.

(Pl. 29, fig. 20)

St. cuspidatum Bréb. Ralfs, 1848, p. 122, t. 22, f. 1, t. 33, f. 10; Nordst. 1873, p. 28; Delp. 1873, p. 136, t. 10, figs. 26–33; Wolle, 1884, p. 123, t. 40, figs. 23–25; Cook. 1887, p. 141, t. 49, f. 5; Nordst. 1888, p. 203; De Toni, 1889, p. 1140; Himerl, 1891, p. 604; W. & G. S. West, 1902a, p. 44; Borge, 1903, p. 107 (*form*); Borge, 1906, p. 44; G. S. West, 1907, p. 124; Printz, 1915, p. 36; Dick, 1919, p. 255; Grönblad, 1920, p. 61; Strom, 1921a, p. 7; Strom, 1921b, p. 18; Borge, 1921, p. 22; W. & G. S. West, 1923, p. 23, pl. 132, figs. 13–15; Smith, 1924, p. 74, pl. 68, figs. 27–34; Allorge, 1924, p. 468; Donat, 1926, p. 20; Strom, 1926, p. 231; Lowe, 1927, p. 312; Borge, 1928, p. 103; Homfeld, 1929, p. 72; Allorge, 1931, p. 364, pl. 13, figs. 1, 2.

Length (semicell) 10μ, breadth 30μ, breadth of isthmus 6μ.

Dist.—Japan, Siberia, Ceylon, Burma, Australia, New Zealand, Greenland, Canada, United States, Brazil, Nova Scotia, Faeroes, England, Wales, Scotland, Ireland, France, Germany, Switzerland, Austria, Galicia, Hungary, Roumania, Italy, Norway, Sweden, Denmark, Spain, Bornholm, Finland, Poland, N. & S. Russia, Abyssinia, E. & C. Africa.

Staurastrum Dickiei Ralfs.

(Pl. 29, figs. 7, 7′)

St. Dickiei Ralfs. Ralfs, 1848, p. 123, t. 21, f. 3; Nordst., 1873, p. 27; Wolle, 1884, p. 122, t. 40, figs. 5, 6, t. 51, figs. 20, 21; Cook. 1887, p. 140, f. 49, f. 3; Nordst. 1888, p. 203; Wittr. & Nordst. 1889, p. 37; De Toni, 1889, p. 1139; Himerl, 1891, p. 604; W. West, 1892, p. 171; Borge, 1901, pp. 5, 27; Borge, 1903, p. 106; Borge, 1906, p. 44; G. S. West, 1907, p. 124; Borge, 1911, p. 19; Printz, 1915, p. 36; Dick, 1919, p. 254; Strom, 1922, p. 11; W. & G. S. West, 1923, p. 3, pl. 129, figs. 14, 15; Smith, 1924, p. 76; Borge, 1925, p. 38; Donat, 1926, p. 20; Strom, 1926, p. 232, Homfeld, 1929, p. 73; Borge, 1930, p. 43; Allorge, 1931, p. 364.

St. laniatum Delp. Delp. 1873, p. 135, t. 10, f. 17.

Length 38μ; breadth, including spines, 52–60μ, length of spines 10μ, breadth of isthmus 12μ.

Dist.—Japan, Siberia, C. China, E. India, Australia, Greenland, United States, Brazil, Paraguay, Patagonia, Faeroes, England, Wales, Scotland, Ireland, France, Germany, Switzerland, Austria, Hungary, Servia, Portugal, Norway, Sweden, Denmark, Spain, Bornholm, Finland, Poland, N. Russia, Nova Zembla, Spitzbergen, C. Africa.

Staurastrum forficulatum Lund.

(Pl. 29, figs. 5, 10)

St. forficulatum Lund. Nordst. 1873, p. 33; De Toni, 1889, p. 1176; W. & G. S. West, 1905, p. 505, t. 7, f. 17; W. & G. S. West, 1909, p. 202; Grönblad, 1920, p. 64; Strom, 1921b, p. 18; W. & G. S. West, 1923, p. 187, pl. 154, figs. 14–16; Strom, 1926, p. 232; Homfeld, 1929, p. 74.

Length, without processes, 40μ; with processes, 45–50μ; breadth, without spines, 36–45μ; with spines, 50–62μ; breadth of isthmus 15μ.

Dist.—Australia, United States, Scotland, Norway, Sweden, Finland, Germany.

New to Asia.

Staurastrum furcigerum Bréb. forma *armigera* (Bréb.) Nordst.

(Pl. 30, fig. 2)

St. pseudofurcigerum Reinsch. Cook. 1887, p. 147, t. 61, f. 4.

St. furcigerum Bréb. forma *armigera* (Bréb.) Nordst. Nordst. 1888, p. 207; W. & G. S. West, 1905, p. 487; W. & G. S. West, 1923, p. 191, pl. 156, f, 10.

St. furcatum var. *armigerum* West. W. West, 1892, p. 174.

Length, without processes, 32μ; including processes, 55μ; breadth, without processes, about 25μ; including processes, 52μ; breadth of isthmus 12μ.

Dist.—India, Australia, New Zealand, United States, England, Wales, Scotland, Ireland, France, Germany, Galicia in Austria, Turkey, Norway, Sweden, Finland, Poland.

New to Japan.

Staurastrum gracile Ralfs.

(Pl. 30, fig. 8)

St. gracile Ralfs. Ralfs, 1848, p. 136, t. 22, f. 12; De Not. 1867, p. 54, t. 5, f. 49; Nordst. 1873, p. 74; Delp. 1873, p. 153, t. 12, figs. 12–21; Wolle, 1884, p. 133, t. 43, figs. 16, 17; Lagerh. 1885, p. 248; Cook. 1887, p. 170, t. 58, f. 6; Nordst. 1888, p. 206; De Toni, 1889, p. 1209; W. West, 1892, p, 181; W. & G. S. West, 1897a, p. 495, t. 6, f. 27; W. & G. S. West, 1898, p. 317, t. 18, f. 7; W. & G. S. West, 1902a, p. 54; W. & G. S. West, 1902b, p. 190; W. & G. S. West, 1903, p. 549, t. 18. f. 10; Borge, 1903, p. 108, t. 4, f. 15 (*form*); Borge, 1906, p. 47; Printz, 1915, p. 37; Dick, 1919, p. 257; Grönblad, 1920, p. 66, t. 3, figs. 98, 99; Strom, 1921b, p. 18; Borge, 1921, p. 23; W. & G. S. West, 1923, p. 96, pl. 144, figs. 3–7; Smith, 1924, p. 88, pl. 73, figs. 16–18; Donat, 1926, p. 22; Lowe, 1927, p. 313; Deflandre, 1928, p. 236; Homfeld, 1929, p. 75, t. 9, f. 96; Allorge, 1931, p. 364, pl. 14, f. 10.

Length 35μ; breadth, including processes, 40μ; breadth of isthmus 11μ.

Dist.—Japan, Siberia, Mongolia, Turkey in Asia, Caucasus, Ceylon, Australia, Greenland, Canada, United States, Cuba, Brazil, Paraguay, England, Wales, Scotland, Ireland, France, Germany, Switzerland, Galicia, Austria, Hungary, Roumania, Italy, Norway, Finmark, Sweden, Spain, Denmark, Bornholm, Finland, Poland, N. Russia, E., S. & C. Africa.

Staurastrum gracile Ralfs var. *nanum* Wille.

(Pl. 29, fig. 9, 18)

St. gracile Ralfs var. *nanum* Wille. De Toni, 1889, p. 1209; W. West, 1892, p. 182; W. & G. S. West, 1897a, p. 495; W. & G. S. West, 1902a, p. 54; W. & G. S. West. 1902b, p. 191; Dick, 1919, p. 257; W. & G. S. West, 1923, p. 100, pl. 144, figs. 8, 9; Donat, 1926, p. 22; Homfeld, 1929, p. 76; Skvortz. 1932, p. 153, pl. 5, fig. 62.

Breadth 20–30μ, breadth of isthmus 5μ.

Dist.—Korea, Ceylon, England, Wales, Scotland, Ireland, Germany, Galicia in Austria, Norway, Finland, Poland.

Staurastrum Hystrix Ralfs.

(Pl. 30, fig. 12, 12′)

St. Hystrix Ralfs. Ralfs, 1848, p. 128 t. 22, f. 5; Nordst. 1873, p. 31; Wolle, 1884, p. 142, t. 45. figs. 14–16; Cook. 1887, p. 151, t. 52, f. 52, f. 3; De Toni, 1889, p. 1167; W. & G. S. West. 1897a, p. 493; Borge, 1906, p. 48; Dick, 1919, p. 257; W. & G. S. West, 1923, p. 60, pl. 136, f. 1; Donat, 1926, p. 20; Strom, 1926, p. 234; Homfeld, 1929, p. 76, t. 9, f. 98; Borge, 1930, p. 48 (*form*); Allorge, 1931, p. 365, pl. 13, figs. 7, 8.

Length, without spines, 25μ; breadth, without spines, 24μ; breadth of isthmus 6 μ.

Dist.—United States, Brazil, England, Wales, Scotland, Ireland, France, Germany, Switzerland, Hungary, Norway, Sweden, Spain, Poland.

New to Asia.

Staurastrum Johnsonii W. & G. S. West.

(Pl. 29, fig. 23)

St. Johnsonii W. & G. S. West. W. & G. S. West, 1896, p. 266. pl. 17, f. 16; Grönblad, 1920, p. 68; Smith, 1924, p. 104. pl. 79, figs. 1–5.

Length 57μ, breadth 80–82μ, breadth of isthmus 12μ.

Dist.—United States, Finland.

New to Asia.

Staurastrum Kurilense sp. nov.

(Pl. 30, figs. 13, 13′, 13″)

Cells of medium size, about as long as broad, sinus open and acute; semicells subtriangular, both dorsal and ventral margins convex, tapering towards the angles to form very short stout processes which end in 3 minute teeth; cell-wall rough with tiny granules, arranged in concentric 3–4 series round the processes, centre of each face with a rounded protuberance ornamented with about 7–14 granules arranged in 2 circles; a distinct circle of small granules around the base, of which 6–7 visible; apex with a circle of about 3 tiny spined denticulations.

Vertical view rhomboidal, elongated at the poles to form short processes, with a prominent subtruncate protuberance in the middle of each lateral margin; apex ornamented by a circle of about 6 (2–3 spined) denticulations.

Cell-wall smooth. Zygospore unknown.

Length 40μ; breadth, including processes, 42–46μ; breadth of isthmus 11–12μ; thickness 30μ.

Loc.—Hyakuike-ga-hara, Shumushu Is.

Staurastrum lunatum Ralfs var. *planctonicum* W. & G. S. West.

(Pl. 30, fig. 6)

St. lunatum Ralfs var. *planctonicum* W. & G. S. West. W. & G. S. West, 1903, p. 546, t. 16, figs. 11, 12; W. & G. S. West, 1906, p. 103; W. & G. S. West, 1909, p. 174; Strom, 1921a, p. 8; Strom, 1921b, p. 18; W. & G. S. West, 1923, p. 30, pl. 133, figs. 20–22; Smith, 1924, p. 71, pl. 68, figs. 11–13; Lowe, 1927, p. 312.

Length 47μ; breadth, without spines, 44–47μ; breadth of isthmus 13μ; length of spines 2–4μ.

Dist.—Canada, United States, England, Wales, Scotland, Ireland, Norway, Finmark, Finland, Russian Lapland.

New to Asia.

Staurastrum margaritaceum (Ehrenb.) Menegh.

(Pl. 30, figs. 10, 10′)

St. margaritaceum (Ehrenb.) Menegh. Relfs, 1848, p. 134, t. 21, f. 9; De Not. 1867, p. 53, t. 5, f. 48; Nordst. 1873, p. 28; Wolle, 1884, p. 125, t. 41, figs. 31–35; Cook. 1887, p. 181, t. 64, f. 12; De Toni, 1889, p. 1227; Himerl, 1891, p. 606; W. West, 1892, p. 186; W. & G. S. West, 1897a, p. 496; W. & G. S. West, 1901, p. 95; Borge, 1903, p. 107; Borge, 1906, p. 46; Dick, 1919, p. 256; Grönblad, 1920, p. 69; W. & G. S. West, 1923, p. 131, pl. 150, figs. 5–9; Borge, 1925, p. 39, t. 1, f. 7 (*form*); Donat, 1926, p. 23; Strom, 1926, p. 235; Lowe, 1927, p. 313; Homfeld, 1929, p. 78; Borge, 1930, p. 46; Allorge, 1931, p. 365.

Length 28μ; breadth, including processes, 22–26μ; breadth of isthmus 8μ.

Dist.—Japan, India, Siam, Java, Celebes, Tasmania, Sandwich Islands, Greenland, Canada, United States, Brazil, England, Wales, Scotland, Ireland, France, Belgium, Germany, Switzerland, Galicia, Austria, Hungary, Norway, Finmark, Sweden, Spain, Finland, N. Russia, Spitzbergen.

Staurastrum megacanthum Lund.

(Pl. 29, figs. 19, 19′)

St. megacanthum Lund. Nordst. 1873, p. 28; Wolle, 1884, p. 121, t. 51, figs. 10–12; Cook. 1887, p. 142, t. 49, f. 7; De Toni, 1889, p. 1141; Borge, 1901, p. 5, f. 28; W. & G. S. West, 1902a, p. 44; Printz, 1915, p. 36; Grönblad, 1920, p. 69, t. 1, f. 41; W. & G. S. West, 1923, p. 20, pl. 131, figs. 7, 8; Smith, 1924, p. 75, pl. 69, figs. 16–21; Lowe, 1927, p. 312; Borge, 1930, p. 44.

Length 40μ; breadth, including spines, 65μ; length of spines 8–12μ; breadth of isthmus 11μ.

Dist.—India, N. & W. Canada, United States, Patagonia, Faeroes, Iceland, England, Wales, Scotland, Ireland, Norway, Sweden, Switzerland, Finland.

New to Japan.

Staurastrum monticulosum Bréb. var. *bifarium* Nordst.

(Pl. 29, fig. 16)

St. monticulosum Bréb. var. *bifarium* Nordst. Nordst. 1873, p. 31, t. 1, f. 14; Wolle, 1884, p. 144, t. 51, figs. 24–26; Nordst. 1888, p. 206; De Toni, 1889, p. 1157; W. & G. S. West, 1895, p. 73, t. 8, f. 21 (*form*); Homfeld, 1929, p. 78.

Breadth, without processes, 30μ; breadth of isthmus 10μ.

Dist.—Australia, United States, Scotland, Germany, Norway, Sweden, Finland, Poland, Madagascar.

New to Asia.

Staurastrum mucronatum Ralfs.

(Pl. 30, fig. 9)

St. mucronatum Relfs. Nordst. 1873, p. 27; Nordst. 1888, p. 203; W. & G. S. West, 1902a, p. 44, t. 2, f. 31; Borge, 1906, p. 44; W. & G. S. West, 1923, p. 11, pl. 130, figs. 10–12; Donat, 1926, p. 20; Strom, 1926, p. 236.

St. dejectum var. *mucronatum* Kirchn. Wolle, 1884, p. 121, t. 40, f. 8; Cook. 1887, p. 139, t. 55, f. 7; De Toni, 1889, p. 1137.

Length 27μ; breadth, without spines, 25–28μ; length of spines 4–5μ, breadth of isthmus 7μ.

Dist.—Siberia, N. India, Alaska, United States, England, Wales, Scotland, Ireland, France, Germany, Galicia in Austria, Roumania, Norway, Sweden, Bornholm, Poland, Spitzbergen.

New to Japan.

Staurastrum natator West.

(Pl. 30, fig. 15)

St. natator West. W. West, 1892, p. 183, t. 23, f. 14; W. & G. S. West, 1909, p. 202; Grönblad, 1920, p. 70; W. & G. S. West, 1923, p. 149, pl. 147, f. 7; Smith, 1924, p. 106, pl. 79, f. 12.

Length, without processes, 17μ (semicell); with processes, 30μ (semicell); breadth, at base of semicell, 16μ; breadth, including processes, 61μ; length of processes 21μ; breadth of isthmus 11μ.

Dist.—United States, Scotland, Ireland, Scandinavia, Finland.

New to Asia.

Staurastrum Ophiura Lund. var. *cambricum* W. & G. S. West.

(Pl. 30, figs. 4, 4′)

St. Ophiura Lund. var. *cambricum* W. & G. S. West. W. & G. S. West, 1923, p. 154, pl. 152, figs. 3, 4.

Length 90μ; breadth, including processes, 120–125μ; breadth of isthmus 21μ.

Dist.—Wales.

New to Asia.

It is an interesting fact that present rarest species is distributed in these Northern Kurile districts.

Staurastrum pilosum (Näg.) Arch.

(Pl. 29, fig. 22)

St. pilosum (Näg.) Arch. Nordst. 1873, p. 30; Cook. 1887, p. 150, t. 52, f. 5; Nordst. 1888, p. 205; De Toni, 1889, p. 1166; W. West, 1892, p. 175; W. & G. S. West, 1897a, p. 494; W. & G. S. West, 1902a, p. 48; Borge, 1906, p. 47; W. & G. S. West, 1923, p. 63, pl. 138, figs. 1–3; Strom, 1926, p. 239, pl. 6, figs. 9, 10; Woronichin, 1926, p. 220; Lowe, 1927, p. 312.

Length, without spines, 47μ; breadth 45μ; breadth of isthmus 13μ.

Dist.—Siberia, Caucasus, Greenland, Canada, Faeroes, Iceland, England, Wales, Scotland, Ireland, Germany, Galicia, Austria, Hungary, Norway, Sweden, Bornholm, Portugal, Finland, N. Russia, Speitzbergen.

New to Japan.

Staurastrum polytrichum (Perty) Rabenh.

(Pl 29, fig. 21)

St. Pringsheimii Reinsh. Cook. 1887, p. 152, t. 52, f. 4.

St. polytrichum (Perty) Rabenh. Nordst. 1873, p. 30; De Toni, 1889, p. 1169; W. West, 1892, p. 175, t. 22, f. 18; Turn. 1893, p. 113, t. 13, f. 16; W. & G. S. West, 1897a, p. 494; W. & G. S. West, 1902a, p. 48; W. & G. S. West, 1903, p. 529; Borge, 1906, p. 48; Printz, 1915, p. 46; Dick, 1919, p. 254, W. & G. S. West, 1923, p. 53, pl. 136, figs. 8–10; Donat, 1926, p. 21; Strom, 1926, p. 239; Lowe, 1927, p. 312; Borge, 1930, p. 48; Allorge, 1931, p. 366.

Breadth, without spines, 55μ; with spines, 70μ; breadth of isthmus 21μ.

Dist.—India, N. & W. Canada, United States, Argentine, England, Wales, Scotland, Ireland, Germany, Switzerland, Galicia, Austria, Norway, Sweden, Spain, Finland, S. Russia.

New to Japan.

Staurastrum scabrum Bréb.

(Pl. 29, fig. 4)

St. scabrum Bréb. Ralfs, 1848, p. 214, t. 35, f. 20; Wolle, 1884, p. 130, t. 41, figs. 29, 30; De Toni, 1889, p. 1170; W. & G. S. West, 1902a, p. 51, t. 2, f. 36; Borge, 1906, p. 48; Dick, 1919, p. 254; Grönblad, 1920, p. 76; Grönblad, 1921, p. 57, pl. 5, f. 16; W. & G. S. West, 1923, p. 81, pl. 140, figs. 1, 2; Strom, 1926, p. 241; Homfeld, 1929, p. 82; Borge, 1930, p. 48.

Breadth 29μ, breadth of isthmus 10μ.

Dist.—Greenland, United States, Faeroes, England, Wales, Scotland, Ireland, France, Germany, Switzerland, Austria, Norway, Sweden, Denmark, Finland, Azores.

New to Asia.

Staurastrum Sebaldi Reinsch.

(Pl. 29, fig. 6)

St. Sebaldi Reinsch. Nordst. 1873, p. 33; Wolle, 1884, p. 138, t. 46, figs. 1–6; Cook. 1887, p. 176; De Toni, 1889, p. 1220; W. West, 1892, p. 184; W. & G. S. West, 1896, p. 267, t. 18, figs. 2, 3; Printz, 1915, p. 37; Grönblad, 1920, p. 76; W. & G. S. West, 1923, p. 166, pl. 148, figs. 5, 6; Strom, 1926, p. 241; Deflandre, 1928, p. 238, f. 173; Homfeld, 1929, p. 82; Borge, 1930, p. 48; Allorge, 1931, p. 366.

Breadth, including processes, 90–92μ.

Dist.—India, Burma (*form*), Australia, New Zealand (*form*), Greenland, United States, Brazil, Faeroes, Iceland (*form*), England, Wales, Scotland, Ireland, Germany, Galicia in Austria, Hungary, Servia, Turkey, Norway, Sweden, Spain, Bornholm, Finland, Poland.

New to Japan.

Staurastrum sexangulare (Bulnh.) Lund.

(Pl. 30, figs. 1, 1′)

St. sexangulare (Bulnh.) Lund. Nordst. 1873, p. 36; Cook. 1887, p. 178, t. 62, f. 3, t. 64, f. 4; De Toni, 1889, p. 1224; W. & G. S. West, 1902b, p. 181; W. & G. S. West, 1903, p. 550; Bernard, 1908, p. 155, f. 279; Printz, 1915, p. 37; Grönblad, 1920, p. 77; Strom, 1921b. p. 18; W. & G. S. West, 1923, p. 194, pl. 157, figs. 2, 3; Donat, 1926, p. 23, pl. 1, f. 3; Strom, 1926, p. 241.

Length, without processes, 40μ; with processes, 70μ; breadth, without processes, 45μ; with processes, 70–90μ; breadth of isthmus 12μ.

Dist.—Japan, C. China, Siberia, India, Ceylon, Burma, Singapore, Java, Australia, New Zealand, England, Wales, Scotland, Ireland, France, Germany, Norway, Sweden, Finland.

Staurastrum spongiosum Bréb. var. *Griffithsianum* (Nag.) Lagerh. (*from*)

(Pl. 29 fig. 17)

St. Griffithsianum Arch. Cook. 1887, p. 154, t. 53, f. 2.

St. spongiosum Bréb. var. *Griffithsianum* (Näg.) Lagerh. Nordst. 1888, p. 207; De Toni, 1889, p. 1174; W. & G. S. West, 1923, p. 78, pl. 140, f. 15.

Breadth 42μ, breadth of isthmus 12μ.

Dist.—Sandwich Isles, Greenland, England, Wales, Germany, Switzerland, Galicia, Austria, Servia, Sweden, Finland, Spitzbergen.

New to Asia.

Stauratrum subavicula W. & G. S. West.

(Pl. 29, fig. 11)

St. subavicula W. &. G. S. West. W. & G. S. West, 1923, p. 181, pl. 155, f. 10.

Length 32μ, breadth 32μ, breadth of isthmus 9μ.

Dist.—Australia, England, Wales, Germany.

New to Asia.

Staurastrum subgrande Borge var. *minor* Smith.

(Pl. 29, figs. 13, 13′)

St. subgrade Borge var. *minor* Smith. Smith, 1924, p. 67, pl. 67, figs. 10–12.

Length 24μ, breadth 35–37μ, breadth of isthmus 15μ.

Dist.—United States.

New to Asia.

This is one of the rarest Desmids, and has only been reported from Wisconsin Lake by Prof. G. M. Smith.

Staurastrum subpygmaeum West var. *subangulatum* W. & G. S. West.

(Pl. 30, fig. 5)

St. subypgmaeum West var. *subangulatum* W. & G. S. West. W. & G. S. West, 1911, p. 163, pl. 124, f. 1.

Length 39μ, breadth 35–37μ, breadth of isthmus 10μ.
Dist.—Scotland.
New to Asia.

Staurastrum teliferum Ralfs.

(Pl. 30, fig. 3)

St. teliferum Ralfs. Ralfs, 1848, p. 128, t. 22, f. 4, t. 34, f. 14; De Not. 1867, p. 50, t. 4, f. 40; Nordst. 1873, p. 30; Delp. 1877, p. 148, t. 11, figs. 1–4; Wolle, 1884, p. 140, t. 45, f. 4; Cook. 1887, p. 151, t. 52, f. 2; Nordst. 1888, p. 205; De Toni, 1889, p. 1167; W. West, 1892, p. 175, t. 24, f. 5; W. & G. S. West, 1897a, p. 493; W. & G. S. West, 1902a, p. 48; Borge, 1906, p. 47; Printz, 1915, p. 36; Dick, 1919, p. 256; Strom, 1921, p. 20; Strom, 1922, p. 11; W. & G. S. West, 1923, p. 58, pl. 136, figs. 2–6; Allorge, 1924, p. 468; Donat, 1926, p. 21; Strom, 1926, p. 242; Guerrero, 1927, p. 17; Deflandre, 1928, p. 238; Homfeld, 1929, p. 84; Borge, 1930, p. 47; Allorge, 1931, p. 367, pl. 13, f. 3.

Breadth, without spines, 36 μ; with spines, 45 μ; breadth of isthmus 10 μ.

Dist.—Japan, Siberia, Burma, Greenland, United States, Brazil, Faeroes, Iceland, England, Wales, Scotland, Ireland, France, Germany, Switzerland, Galicia, Austria, Servia, Roumania, Italy, Norway, Sweden, Denmark, Spain, Bornholm, Finland, N. & S. Russia, Azores.

Staurastrum tumidum Bréb.

(Pl. 30, figs. 14, 14′)

St. tumidum Bréb. Ralfs, 1848, p. 126, t. 21, f. 6; Nordst. 1873, p. 37; Wolle, 1884, p. 120, t. 39, figs. 1, 2; Cook. 1887, p. 165, t. 55, f. 8, t. 57, f. 1; De Toni, 1889, p. 1201; W. West, 1892, p. 180; Nordst. 1896, p. 263; W. & G. S. West, 1905, p. 486; W. & G. S. West, 1911, p. 142, pl. 122, figs. 1–5; Printz, 1915, p. 34; Grönblad, 1920, p. 80; Donat, 1926, p, 21; Strom, 1926, p. 242; Homfeld, 1929, p. 84; Borge, 1930, p. 49; Allorge, 1931, p. 367.

Length 122 μ, breadth 98–100 μ, breadth of isthmus 57 μ.
Dist.—United States, England, Wales, Scotland, Ireland, France,

Germany, Galicia in Austria, Norway, Denmark, Sweden, Spain, Bornholm, Finland.

New to Asia.

This characteristic species is one of the rarest Desmids in the Northern Kuriles and only a few specimens I could observed.

Staurastrum vestitum Ralfs.

(Pl. 29, fig. 12)

St. vestitum Ralfs. Ralfs. 1848, p. 142, t. 23, f. 1; Nordst. 1873, p. 34; Delp. 1877, p. 159, t. 12, figs. 46–49; Wolle, 1884, p. 138, t. 45, figs. 28–30; Cook. 1887, p. 175, t. 60, f. 3; Nordst. 1888, p. 206; De Toni, 1889, p. 1218; W. & G. S. West, 1897a, p. 496; G. S. West, 1899, pp. 374, 395; W. & G. S. West, 1902a, p. 240; W. & G. S. West, 1923, p. 158, pl. 151, figs. 9–11, pl. 152, figs. 5, 6; Smith, 1924, p. 92, pl. 75, figs. 4, 5; Donat, 1926, p. 23; Strom, 1926, p. 242; Homfeld, 1929, p. 84; Borge, 1930, p. 49; Allorge, 1931, p. 367, pl. 14, f. 7.

Breadth, including processes, 55μ.

Dist.—Japan, Australia, N. & W. Canada, United States, Brazil, England, Wales, Scotland, Ireland, France, Belgium, Germany, Switzerland, Galicia in Austria, Hungary, Italy, Norway, Sweden, Denmark, Spain, Bornholm, Finland, Poland, S. Russia, Azores.

Gen. Sphaerozosma Corda, 1835.

Sphaerozosma Aubertianum West var. *Archeri* (Gutw.) W. & G. S. West.

(Pl. 31, fig. 11)

Sph. Aubertianum West. var. *Archeri* (Gutw.) W. & G. S. West. W. & G. S. West, 1896, p. 230; W. & G. S. West. 1905, p. 505, t. 6, f. 7; Grönblad, 1920, p. 83; W. & G. S. West, 1923, p. 208, pl. 159, figs. 14–17; Allorge, 1924, p. 468; Smith, 1924, p. 137, pl. 86, f. 16.

Length 13—17 μ, breadth 22–28 μ, breadth of isthmus 7–8 μ.

Dist.—India, Australia, United States, England, Wales, Scotland, Sweden, Poland, Finland.

New to Japan.

Sphaerozosma granulatum Roy & Biss.

(Pl. 31, fig. 7)

Sph. granulatum Roy & Biss. Roy & Biss., 1886, p. 242, f. 17; De Toni, 1889, p. 791; Heimerl, 1891, p. 588; W. West, 1892, p. 115; Borge, 1901, p. 17; W. & G. S. West, 1902a, p. 59; W. & G. S. West, 1902b, p. 193; Borge, 1903, p. 120; Printz,

1915, p. 38; Grönblad, 1920, p. 83; Borge, 1921, p. 23; W. &, G. S. West, 1923, p. 213, pl. 160, figs. 6, 7; Donat, 1926, p. 23; Strom, 1926, p. 243; Homfeld, 1929, p. 85; Borge, 1930, p. 55.

Length 9–11 μ, breadth 8–10 μ, breadth of isthmus 4–6 μ.

Dist.—Japan, Manchuria, C. China, Ceylon, Java, Australia, New Zealand, Nova Scotia, United States, Parto Rico, Colombia, Brazil, Paraguay, Patagonia, England, Wales, Scotland, Ireland, Germany, Galicia, Austria, Norway, Sweden, Bornholm, N. Russia, Germany, Finland.

Gen. **Spondylosium** Bréb. 1844.

Spondylosium planum (Wolle) W. & G. S. West.

(Pl. 31, fig. 6)

Sphaerozosma pulchrum var. *planum* Wolle. Wolle, 1884, p. 29, t. 4, figs. 3, 4; De Toni, 1889, p. 794.

Spondylosium ovale Turn. Turn, 1893, p. 44, t. 18, figs. 3, 9.

Sp. pulchrum var. *planum* W. & G. S. West. W. & G. S. West, 1903, p. 551.

Sp. planum (Wolle) W. & G. S. West. Strom, 1921b, p. 20, pl. 1, f. 8; W. & G. S. West, 1923, p. 222, pl. 160, figs. 23–25; Allorge, 1924, p. 469; Smith, 1924, p. 140, pl. 86, f. 22, pl. 87, figs 1, 2; Strom, 1926, p. 243; Lowe, 1927, p. 314; Homfeld, 1929, p. 86; Borge, 1930, p. 54.

Length 8–9 μ, breadth 11–13 μ, breadth of apex 9 μ, breadth of isthmus 7 μ.

Dist.—Alaska, Canada, United States, England, Wales, Scotland, Ireland, Sweden, Norway, France, Germany.

New to Asia.

Gen. **Hyalotheca** Ehrenb. 1840.

Hyalotheca dissiliens (Sm.) Bréb.

(Pl. 31, fig. 2)

Gloeoprium dissiliens Hass. Hass. 1845, p. 346, t 8[illegible], f. 34.

Hyalotheca dissiliens (Sm.) Bréb. Ralfs, 1848, p. 51, t. 1, f. 1; De Bary, 1858, p. 76; De Not. 1867, p. 25, t. 1, f. 1; Nordst. 1873, p. 48; Delp. 1873, p. 47; Wolle 1884, p. 22, t. 1, figs. 3–12, t. 24, f. 26; Lagerh. 1885, p. 228; Cook. 1887, p. 7, t. 3, f. 1; De Toni, 1889, p. 785; Himerl, 1891, p. 588; W. West, 1892, p. 116; Lütkemüller, 1892, p. 2; Turn. 1893, p. 151; W. & G. S. West, 1897a, p. 497; W. & G. S. West, 1899, p. 284; W. & G. S. West, 1901, p. 97; W. & West, 1902b, p. 195; W. & G. S. West, 1902a, p. 60; Borge, 1903, p. 122; Borge, 1906, p. 53; Bernard, 1908, p. 55; Borge, 1911. p. 203; Printz, 1915, p. 39; Higashi, 1916, p. 284; Grönblad, 1920, p. 84; Strom, 1921a, p. 8; Strom, 1922, p. 11; W. & G. West, 1923, p. 229, pl. 161, figs. 16–27; Allorge, 1924, p. 469; Borge, 1925, p. 44; Smith, 1924, p. 142, pl. 87, f. 10; Donat, 1926, p. 24;

Strom, 1926, p. 243; Woronichin, 1926, p. 220; Lowe, 1927, p. 314; Homfeld, 1929, p. 86; Borge, 1930, p. 55; Allorge, 1931, p. 368, pl. 15, f. 9.

Length 12–14μ, breadth 18–20μ, breadth of apices 17–18μ.

Dist.—Japan, Siberia, C. China, India, Ceylon, Burma, Siam, Singapore, Java, Caucasus, Australia, Greenland, N. & W. Canada, United States, W. Indies, Guiana, Colombia, Brazil, Paraguay, Argentine, Faeroes, England, Wales, Scotland, Ireland, France, Germany, Switzerland, Austria, Hungary, Roumania, Turkey, Italy, Portugal, Norway, Finmark, Sweden, Denmark, Spain, Bornholm, Finland, Poland, N., S. & C. Russia, Nova Zembla, Spitzbergen, E. & C. Africa, Azores.

Hyalotheca dissiliens (Sm.) Bréb. var. *tatrica* Racib.

(Pl. 31, fig. 3)

H. dissiliens (Sm.) Breb. var. *tatrica* Racib. De Toni, 1889, p. 786; W. & G. S. West, 1925, p. 234, pl. 162, f. 19.

Length 17μ, breadth 18μ, breadth of apices 15–16μ.

Dist.—England, Galicia in Austria, Poland, E. Africa.

New to Asia.

Hyalotheca Indica Turn.

(Pl. 31, fig. 12)

H. Indica Turn. Turn. 1893, p. 152, t. 22, f. 17; W. & G. & West, 1902b, p. 195; W. & G. S. West, 1905, p. 505, t. 6, f. 6; W. & G. S. West, 1923, p. 237, pl. 162, f. 10.

Length 13–15μ, breadth 12–14μ, breadth of apices 11–12μ, breadth of isthmus 10–11μ.

Dist.—India, Ceylon, England, Scotland, Ireland.

New to Japan.

Hyalotheca mucosa (Mert.) Ehr.

(Pl. 31, fig. 8)

H. mucosa (Mert.) Ehr. Ralfs, 1848, p. 53, t. 1, f. 2; De Not. 1867, p. 26, t. 1, f. 2; Nordst. 1873, p. 48; Wolle, 1884, p. 23, t. 1, f. 13; Lgerh. 1885, p. 228; Cook. 1887, p. 8, t. 3, f. 2; Nordst. 1888, p. 208; De Toni, 1889, p. 787; W. West, 1892, p. 117; Lütkemüller, 1892, p. 3; W. & G. S. West, 1897a, p. 497; Borge, 1901, p. 17; Borge, 1903, p. 122; Borge, 1906, p. 52; W. & G. S. West, 1907, p. 131, t. 4, figs. 4, 5; Gröniblad, 1920, p. 84, W. & G. S. West, 1923, p. 235, pl. 162, figs. 1–4; Allorge, 1924, p. 469; Smith, 1924, p. 142, pl. 87, f. 10; Borge, 1925, p. 44; Donat, 1926, p. 24; Strom, 1926, p. 244; Lowe, 1927, p. 314; Homfeld, 1929, p. 86; Allorge, 1931, p. 369, pl. 15, f. 8.

Gloeoprium mucosum Ralfs. Hass. 1845, p. 347, t. 83, figs. 5, 6.
Mixotaenium armillare Delp. Delp., 1873. p. 50, t. 1, figs. 13–19.

Length 18–22μ, breadth 18–20μ, breadth of apices 17–18μ.

Dist.—India, Australia, Alaska, N. & W. Canada, United States, Brazil, Patagonia, England, Wales, Scotland, Ireland, France, Germany, Switzerland, Galicia, Austria, Hungary, Italy, Spain, Portugal, Norway, Sweden, Bornholm, Finland, Poland, S. Russia, C. Africa.

New to Japan.

Gen. **Desmidium** Ag. 1824.

Desmidium Aptogonum Bréb.

(Pl. 31, fig. 4)

D. Aptogonum Bréb. De Bary, 1858, p. 76, t. 6, figs.55, 56; Nordst. 1873, p. 50; Wolle, 1884, p. 27, t. 2, figs. 6, 7, t, 49, f. 7; Lagerh. 1885, p. 227; Cook. 1887, p. 11, t. 5, f. 1; De Toni, 1889, p. 781; W. West, 1892, p. 117; Turn. 1893, p. 147; W. & G. S. West, 1896, p. 233, t. 12, f. 24; W. & G. S. West, 1902b, p. 193; Borge, 1903, p. 122; Borge, 1906, p. 51; W. & G. S. West, 1907, p. 226; Grönblad, 1920, p. 84; Strom, 1921b, p. 20; W. & G. S. West, 1923, p. 242, pl. 164, figs. 1–3; Allorge, 1924, p. 469; Smith, 1924, p. 144, pl. 88, figs. 3, 4; Borge, 1925, p. 46; Donat, 1926, p. 24; Homfeld, 1929, p. 87; Allorge, 1931, p. 369.

Aptogonum Desmidium Ralfs. Ralfs, 1848, p. 64, t. 32, figs. 1a–d; Delp. 1873, p. 61, t. 3, figs. 1–5.

Desmidium Swartzii Wallich. var. *amblyodon* W. & G. S. West. W. & G. S. West, 1895, p. 43, t. 9, figs. 34, 35.

Length 16–20, breadth 23–26μ, breadth of isthmus 20–21μ.

Dist.—Japan, India, Ceylon, Burma, Java, Australia, Sandwich Isles, United States, Brazil, Ecuador, Colombia, England, Wales, Scotland, Ireland, France, Germany, Switzerland, Galicia, Austria, Turkey, Italy, Norway, Sweden, Denmark, Finland, Madagascar.

Desmidium Baileyi (Ralfs) Nordst.

(Pl. 31, fig. 1)

Aptogonum Baileyi Ralfs. Ralfs, 1848, p. 208, pl. 35, figs. 1a–c; Delp. 1877, p. 63, t. 3, f. 16.

Desmidium Baileyi (Ralfs) Nordst. Borge, 1903, p. 122 (*form*); Smith, 1924, p. 145, pl. 88, figs. 5–7; Borge, 1925, p. 46; Lowe, 1927, p. 314.

D. Baileyi De Bary. De Bary, 1858, p. 50; W. & G. S. West, 1902b, p. 193; Borge, 1928, p. 104.

Length 23–25μ, breadth 22μ.

Dist.—Java, Ceylon, Canada, United States, Brazil, Italy, Africa.

New to Japan.

Desmidium coarctatum Nordst. var. *cambricum* West.

(Pl. 31, fig. 9)

D. coarctatum Nordst. var. *cambricum* West. W. & G. S. West 1905, p. 505, t. 4, no. 5, f. 1; W. & G. S. West, 1923, p. 252, pl. 165, figs. 3, 4.

Length 25–30μ, breadth 36–38μ, breadth of apex 20–22μ, breadth of isthmus 32–34μ.

Dist.—Wales, Scotland.

New to Asia.

Desmidium Swartzii Ag.

(Pl. 31, fig. 5)

Desm. Swartzii Ag. Hass. 1845, p. 344, t. 83, figs. 7, 8; Ralfs, 1848, p. 61, t. 4; De Bary, 1858, p. 76, f. 57; Nordst. 1873, p. 49, Delp. 1873, p. 56, t. 2, figs. 8–12; Cohn, 1879, p. 5; Wolle, 1884, p. 26, t. 2, figs. 1–5; Cook., 1887, p. 10, t. 5, f. 2; Nordst. 1888, p. 209; De Toni, 1889, p. 780; Himerl, 1891, p. 589; W. West, 1892, p. 117; W. & G. S. West. 1897a, p. 497; W. & G. S. West, 1902a, p. 59; Borge, 1903, p. 122; Borge, 1906, p. 52; Printz, 1915, p. 38; Dick, 1919, p. 260; Grönblad, 1920, p. 85; Strom, 1922, p. 11; W. & G. S. West, 1923, p. 246, pl. 163, figs. 5–8; Allorge, 1924, p. 469; Smith, 1924, p. 144, pl. 88, figs. 1, 2; Donat, 1926, p. 24, Strom, 1926, p. 244; Woronichin. 1926, p. 220; Lowe. 1927, p. 314; Homfeld, 1929, p. 88; Borge, 1930, p. 55; Allorge, 1931, p. 369.

Length 15–17μ, breadth 30–35μ, breadth of isthmus 25–27μ.

Dist.—Japan, India, Burma, Caucasus, Australia, New Zealand, Greenland, Canada, United States, Colombia, Brazil, Paraguay, England, Wales, Scotland, Ireland, France, Germany, Switzerland, Galicia, Austria, Hungary, Servia, Roumania, Turkey, Italy, Spain, Portugal, Norway, Sweden, Denmark, Finland, Poland, N., S. & C. Russia.

Gen. Gymnozyga Ehrenb. 1841.

Gymnozyga moniliformis Ehrenb. var. *gracilescens* Nordst.

(Pl. 31, fig. 10)

Bambusina Brebissoni Kütz. var. *gracilescens* Woll. Wolle, 1884, p. 25.

Gymnozyga moniliformis Ehrenb. var. *gracilescens* Nordst. Nordst. 1888, p. 209; De Toni, 1889, p. 798; W. & G. S. West, 1896, p. 232, t. 12, f. 19; W. & G. S. West, 1902b, p. 194; W. & G. S. West, 1905, p. 506; Borge, 1906, p. 52; Strom, 1921b, p. 20; W. & G. S. West, 1923, p. 256, pl. 166, f. 10, pl. 166, f. 10; Borge, 1925, p. 46; Strom, 1926, p. 244; Homfeld, 1929, p. 88.

Length 25–27μ, breadth 20–22μ, breadth of apices 12μ.

Dist.—Ceylon, Java, United States, Brazil, Scotland, Sweden, Norway, Germany.

New to Japan.

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Plate XVII

Figs.		*Page*
1.	*Gonatozygon monotaenium* De Bary. ×400	137
2.	*Spirotaenia condensata* Bréb. ×400	138
3.	*Penium rufescens* Cleve. ×400	141
4.	*Mesotaenium Kramstai* Lemm. ×400	138
5.	*Netrium oblongum* (De Bary) Lütkem. ×400	140
6.	*Netrium Digitus* (Ehrenb.) Itzigs. & Rothe. ×400	139
7.	*Penium spirostriolatum* Barker. ×400	142
8.	*Penium Cylindrus* (Ehrenb.) Bréb. ×400	140
9.	*Penium minutum* (Ralfs) Cleve var. *crassum* West. ×400	141
10.	*Penium minutum* (Ralfs) Cleve. ×400	141
11.	=6. ×400	
12.	*Penium Libellula* (Focke) Nordst. ×400	140
13.	*Netrium Nägelii* (Bréb.) W. & G. S. West. ×400	139
14.	*Genicularia elegans* W. & G. S. West. ×400	138

PL. XVII.

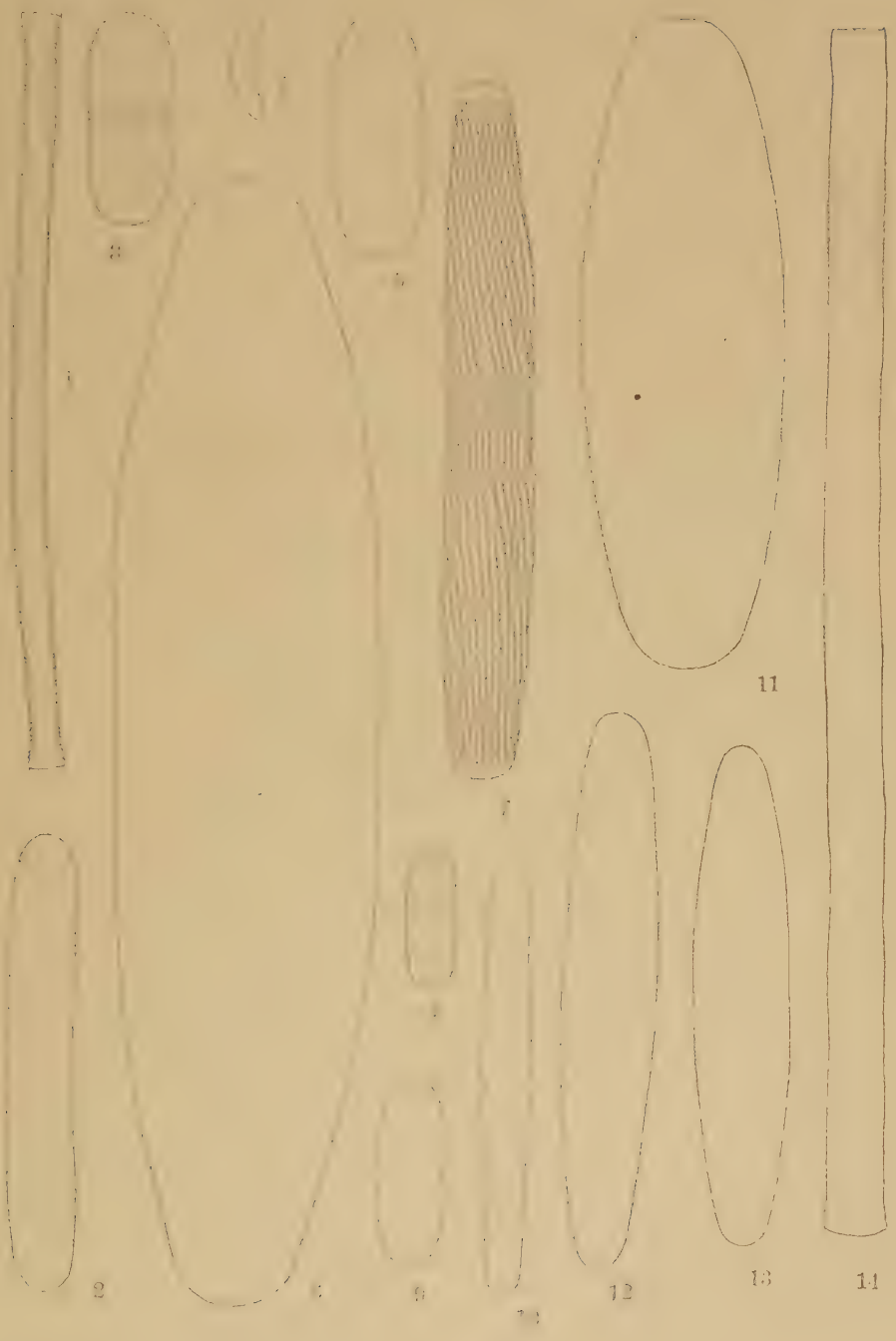

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Plate XVIII

Figs.		*Page*
1.	*Closterium angustatum* Kütz. ×400	142
2.	*Closterium costatum* Corda. ×400	143
3.	*Closterium Ralfsii* Bréb. var. *hybridum* Rabenh. ×300	147
4.	*Closterium intermedium* Ralfs var. *hibernicum* West. ×400	145
5.	*Closterium Dianæ* Ehrenb. ×400	144
6.	*Closterium gracile* Bréb. ×400	145
7.	*Closterium parvulum* Näg. ×400	147
8.	*Closterium Cynthia* De Not. ×400	143
9.	*Closterium Jenneri* Ralfs. ×400	146

PL. XVIII.

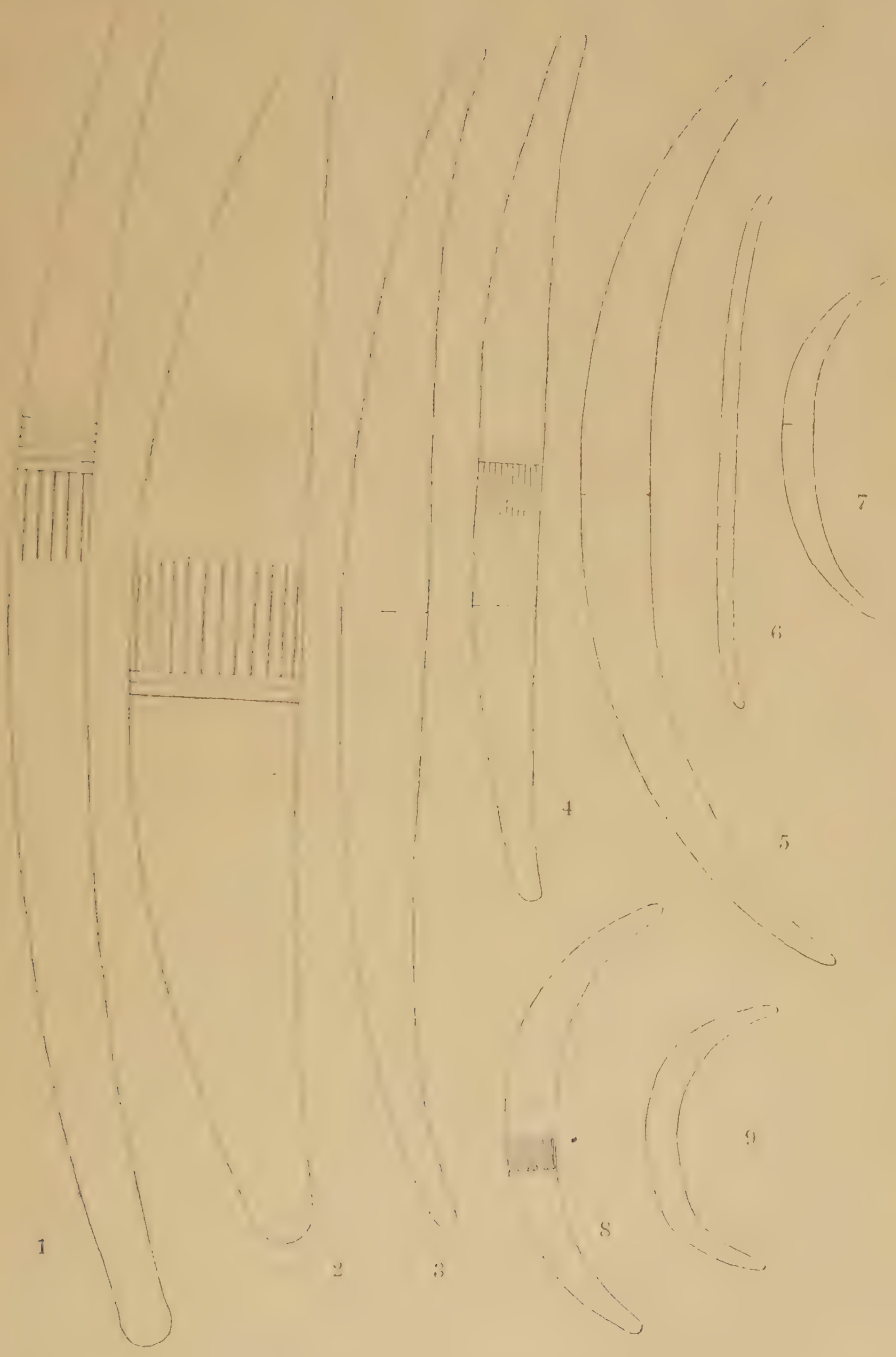

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Plate XIX

Figs.		*Page*
1, 2.	*Closterium gracile* Bréb. var. *elongatum* W. & G. S. West. ×400	145
3.	*Closterium Kützingii* Bréb. ×400	146
4.	*Closterium rostratum* Ehrenb. ×400	148
5.	*Closterium attenuatum* Ehrenb. ×300	143
5′.	=5. ×400	
6.	*Closterium didymotocum* Corda. ×400	144
7.	*Closterium Lunula* Ehrenb. var. *biconvexum* Schmidle. ×400	147

PL. XIX.

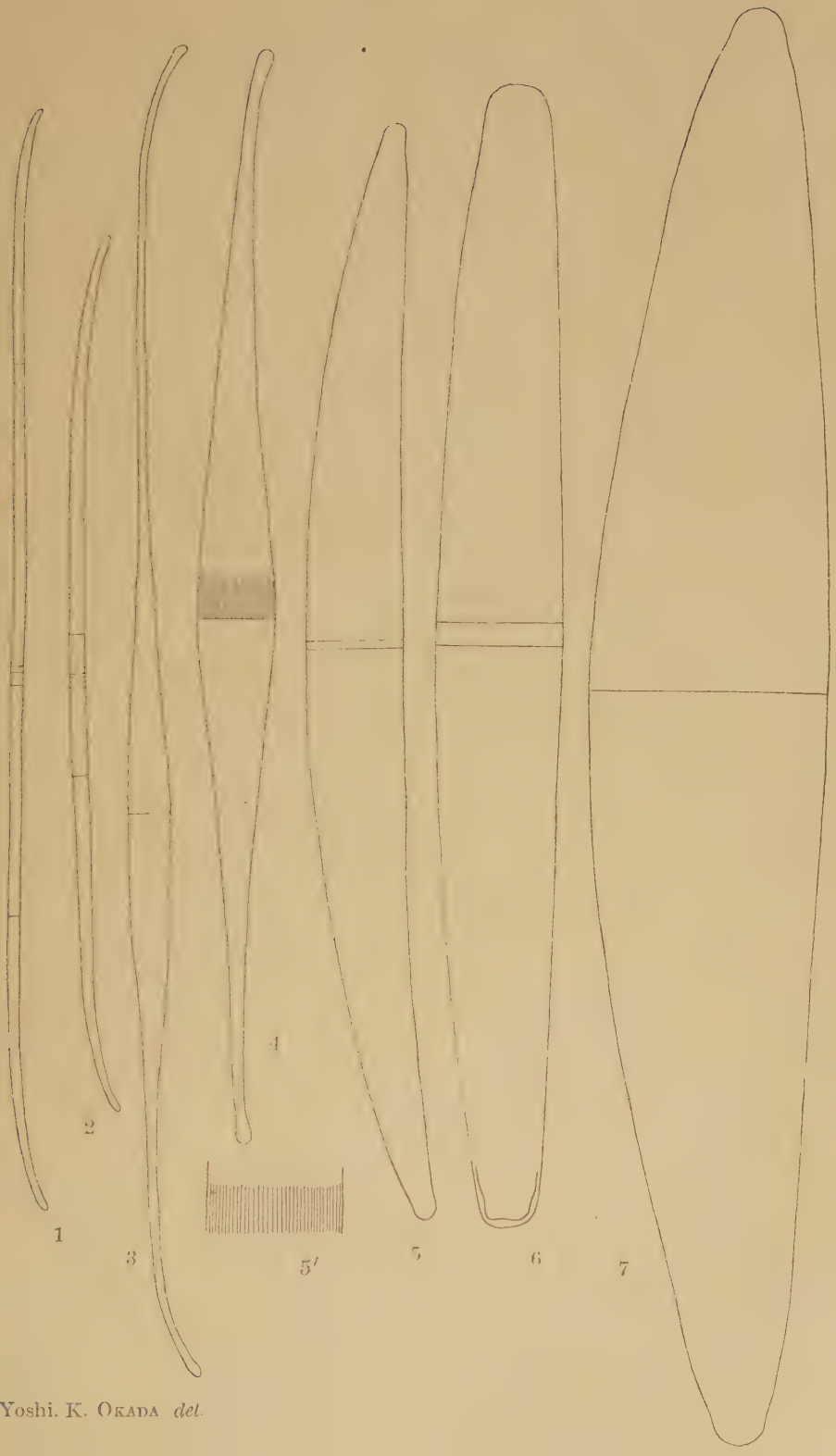

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Plate XX

Figs.		*Page*
1.	*Pleurotaenium truncatum* (Bréb.) Näg. ×400	149
2.	*Pleurotaenium coronatum* (Bréb.) Rabenh. var. *fluctuatum* West. ×300	148
3.	*Pleurotaenium Ehrenbergii* (Bréb.) De Bary. ×300	148
4, 5.	*Tetmemorus laevis* (Kütz.) Ralfs. (4, side view) ×400	151
6, 7.	*Tetmemorus granulatus* (Bréb.) Ralfs var. *attenuatus* West. (7, side view) ×400	151
8.	*Pleurotaenium Trabecula* (Ehrenb.) Näg. var. *rectissimum* W. & G. S. West. ×300	149
9.	*Tetmemorus granulatus* (Bréb.) Ralfs. ×400	150
10, 11.	*Tetmemorus Brébissonii* (Menegh.) Ralfs var. *minor* De Bary. (11, side view) ×400	150
12.	*Pleurotaenium Ehrenbergii* (Bréb.) De Bary. (*form*) ×300	148

PL. XX.

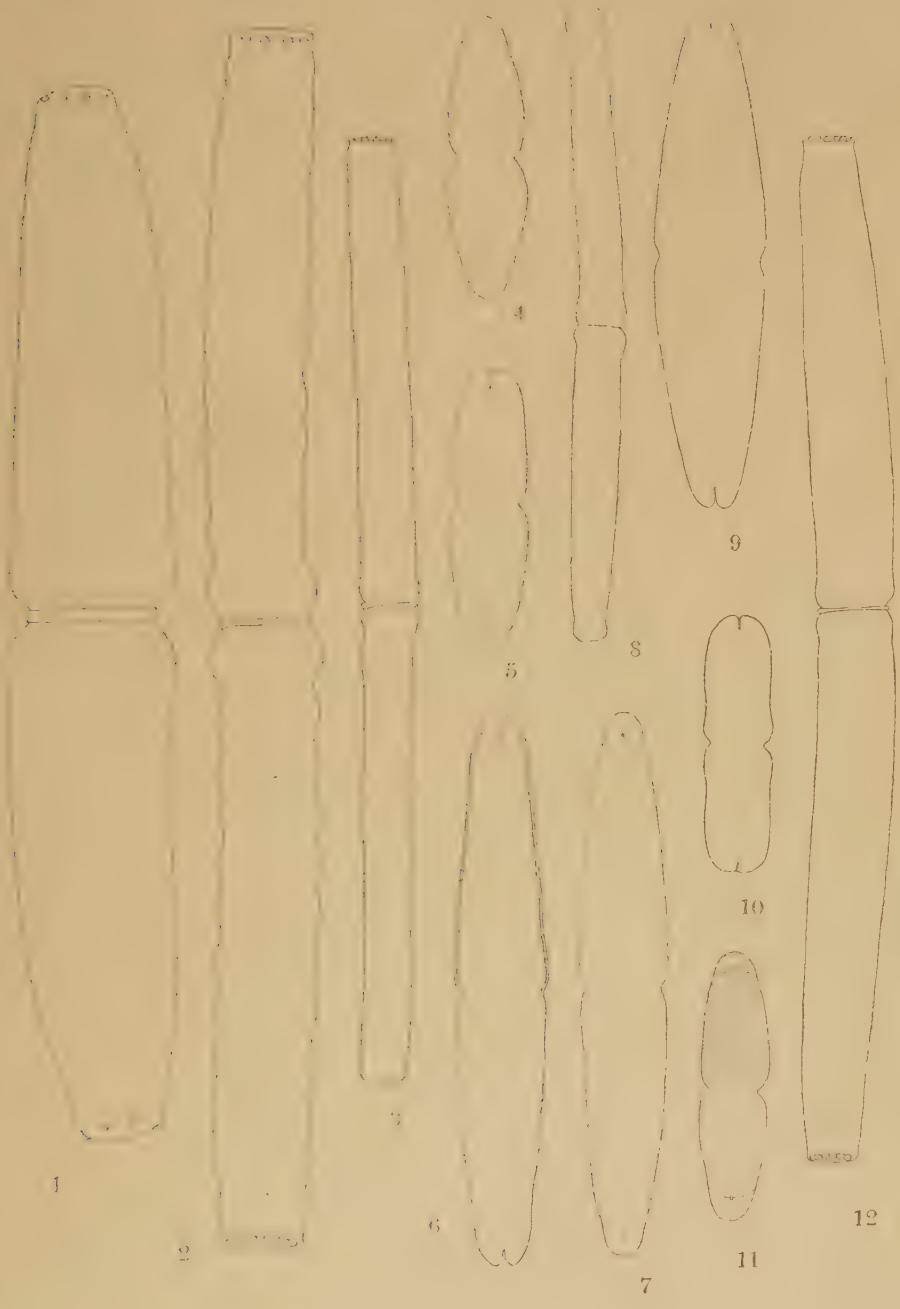

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Plate XXI

Figs. *Page*

1. *Micrasterias denticulata* Bréb. var. *angulosa* (Hantzsch) W. & G. S. West. ×400 159
2. *Micrasterias pinnatifida* (Kütz.) Ralfs. ×400 161
3. *Euastrum Didelta* (Turp.) Ralfs. (*form*) ×400 153
4. *Euastrum gemmatum* Bréb. ×400 154
5. *Euastrum aboense* Elfv. ×400 151
6. *Euastrum verrucosum* Ehrenb. var. *rhomboideum* Lund. ×400 157
7. *Euastrum oblongum* (Grev.) Ralfs. ×400 155

PL. XXI.

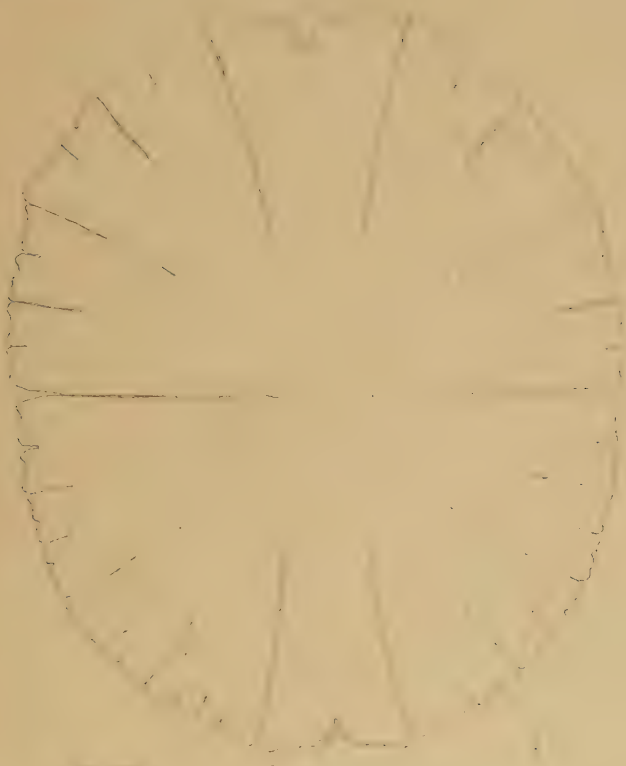

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Plate XXII

Figs.		*Page*
1, 2.	*Euastrum crassum* (Bréb.) Kütz. (1, vertical view) ×400	153
3.	*Euastrum elegans* (Bréb.) Kütz. var. *pseudelegans* (Turn.) W. & G. S. West. ×400	154
4.	*Euastrum bidentatum* Näg. ×400	152
5, 6.	*Micrasterias Thomasiana* Arch. ×400	162
7, 8.	*Euastrum pectinatum* Bréb. var. *brachylobum* Wittr. (7, vertical view) ×400	156
9.	*Euastrum ansatum* Ralfs. ×400	152

PL. XXII.

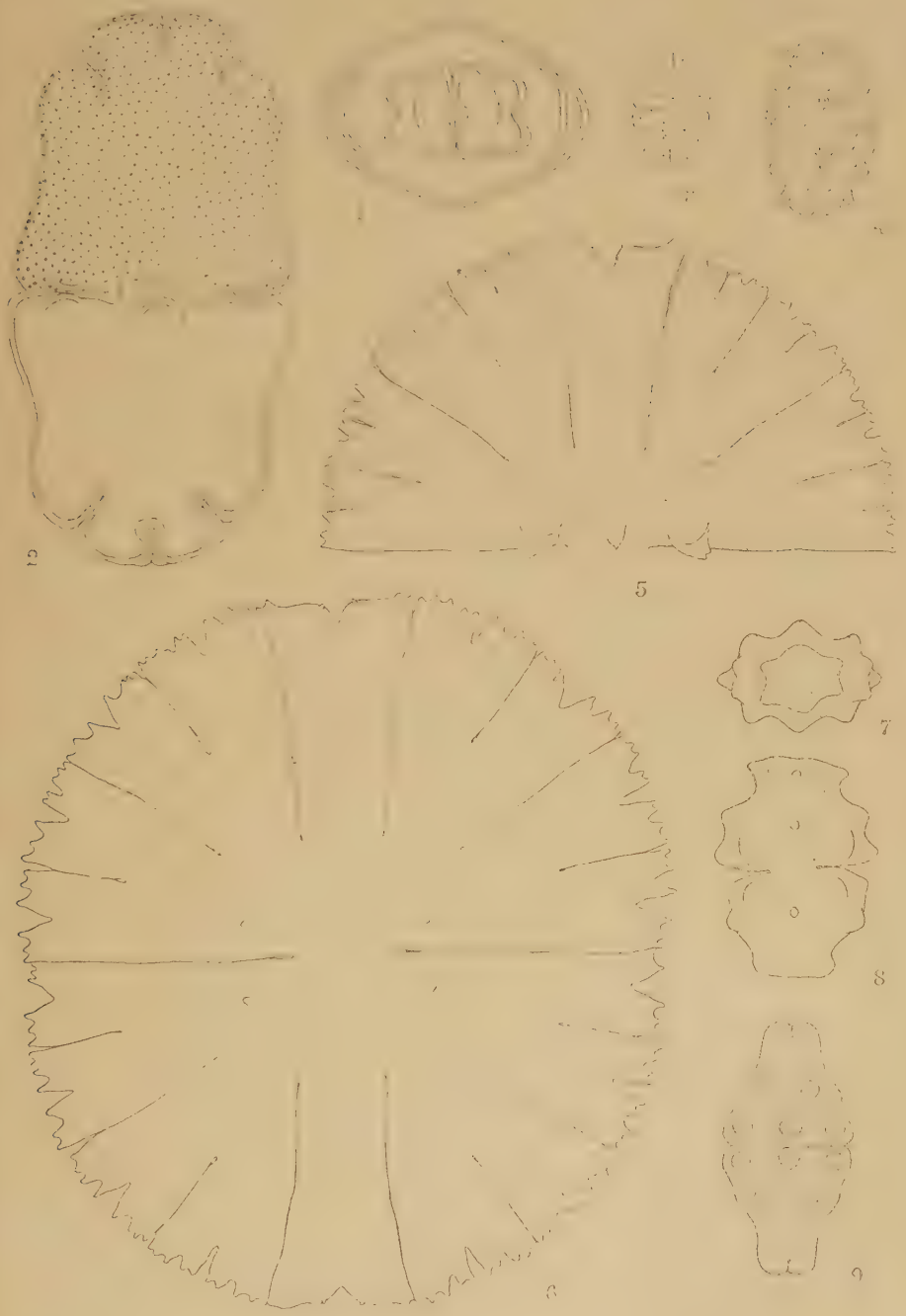

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Plate XXIII

Figs.		*Page*
1.	*Euastrum obesum* Josh. ×400	155
2.	*Euastrum montanum* W. & G. S. West. ×400	155
3.	*Euastrum cuneatum* Jenner. ×400	153
4, 5.	*Micrasterias rotata* (Grev.) Ralfs. ×400	161
6.	*Euastrum sinuosum* Lenorm. var. *reductum* W. & G. S. West. ×400	156
7.	*Euastrum sublobatum* Bréb. ×400	157
8.	*Euastrum dubium* Näg. ×400	154

PL. XXIII.

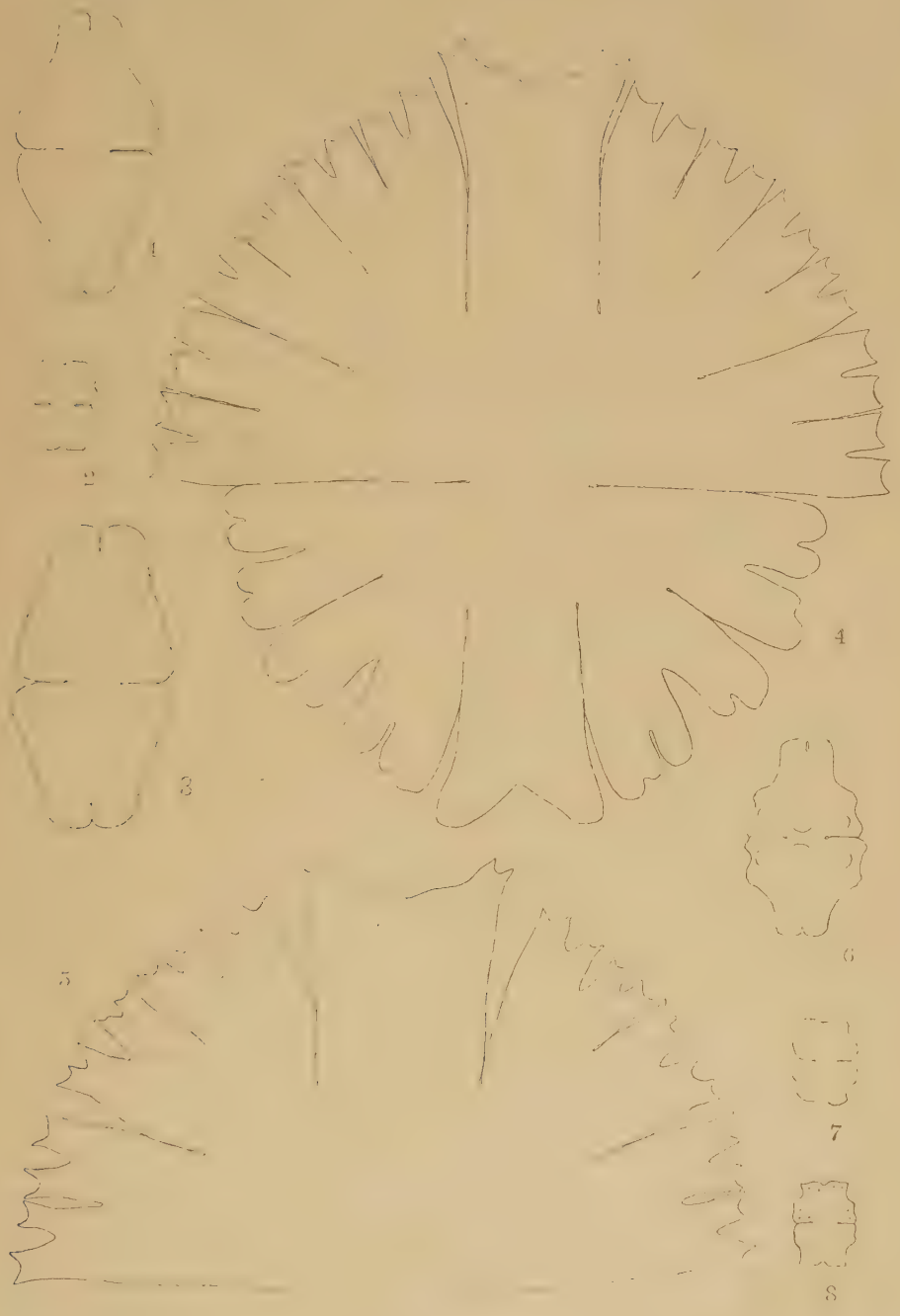

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Plate XXIV

Figs.		*Page*
1, 2.	*Micrasterias truncata* (Corda)Bréb. ×400. (*small form*)	162
3.	*Euastrum verrucosum* Ehrenb. var. *reductum* Nordst. ×400	157
4.	*Micrasterias denticulata* Bréb. var. *notata* Nordst. ×400	160
5.	*Euastrum pinnatum* Ralfs. ×400	156
6.	*Micrasterias denticulata* Bréb. var. *notata* Nordst. forma *minor* Okada *f. nov.* ×400	160

PL. XXIV.

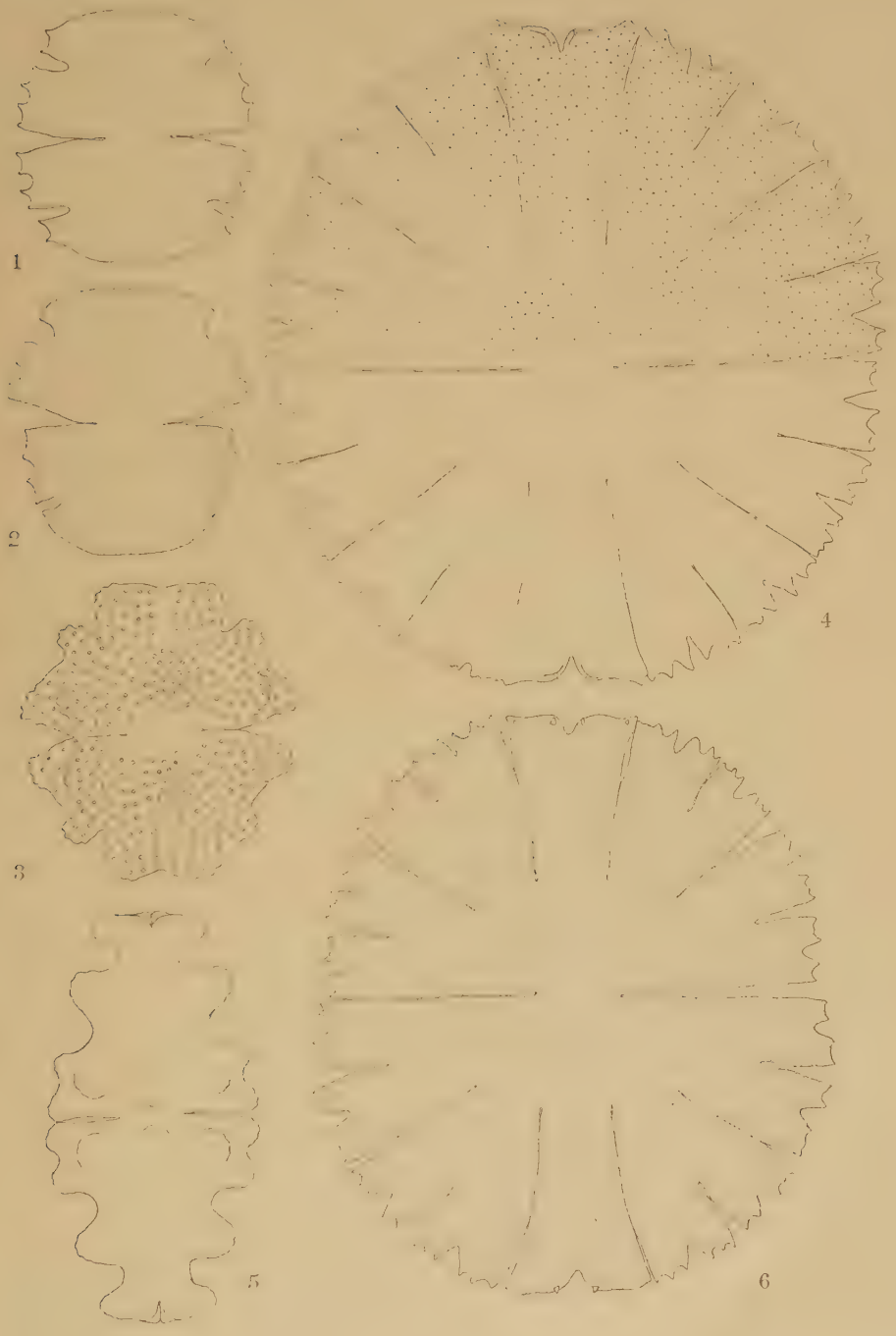

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Plate XXV

Figs.		*Page*
1. 2.	*Micrasterias papillifera* Bréb. ×400	160
3.	*Micrasterias Americana* (Ehrenb.) Ralfs. ×400	158
4.	*Micrasterias Crux-melitensis* (Ehrenb.) Hass. ×400	158
5.	*Micrasterias truncata* (Corda) Bréb. ×400	162
6.	*Micrasterias denticulata* Bréb. var. *angustosinuata* Gay. ×400	159

PL. XXV.

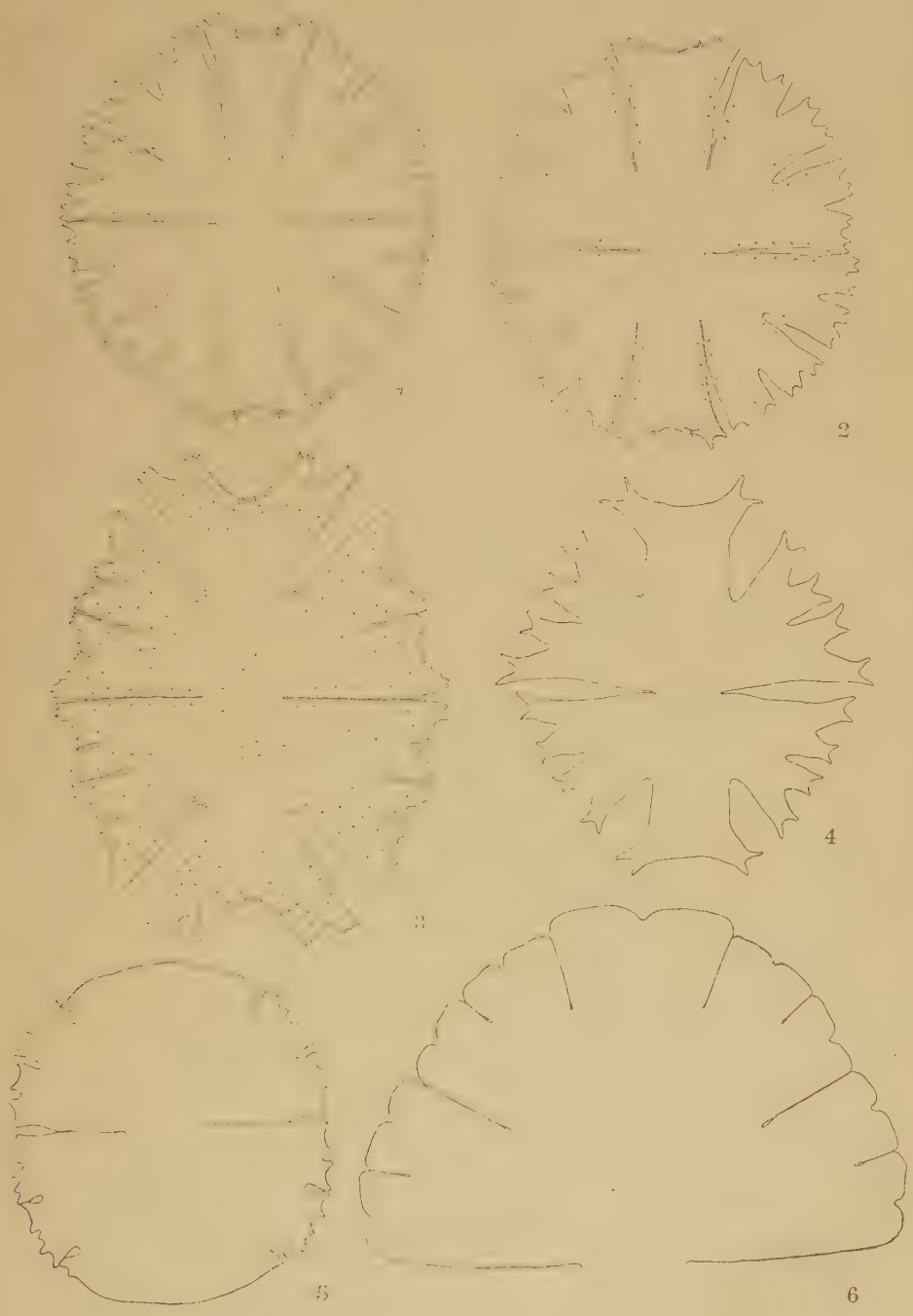

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Plate XXVI

Figs.		*Page*
1.	*Cosmarium tetraophthalmum* Bréb. ×600	172
2.	*Cosmarium Hammeri* Reinsch var. *protuberans* W. & G. S. West. ×600	167
3.	*Cosmarium venustum* (Bréb.) Arch. ×600	173
4.	*Cosmarium Boeckii* Wille. ×600	163
5.	*Cosmarium Holmiense* Lund. var. *integrum* Lund. ×600	167
6.	*Cosmarium impressulum* Elfv. ×600	167
7.	*Cosmarium Cucurbita* Bréb. ×600	164
8.	*Cosmarium cyclicum* Lund. var. *arcticum* Nordst. ×600	165
9.	*Cosmarium globosum* Bulnh. ×600	166
10.	*Micrasterias denticulata* Bréb. ×400	159
11.	*Cosmarium margaritiferum* Menegh. ×600	168
12.	*Cosmarium galeritum* Nordst. ×600	165

PL. XXVI.

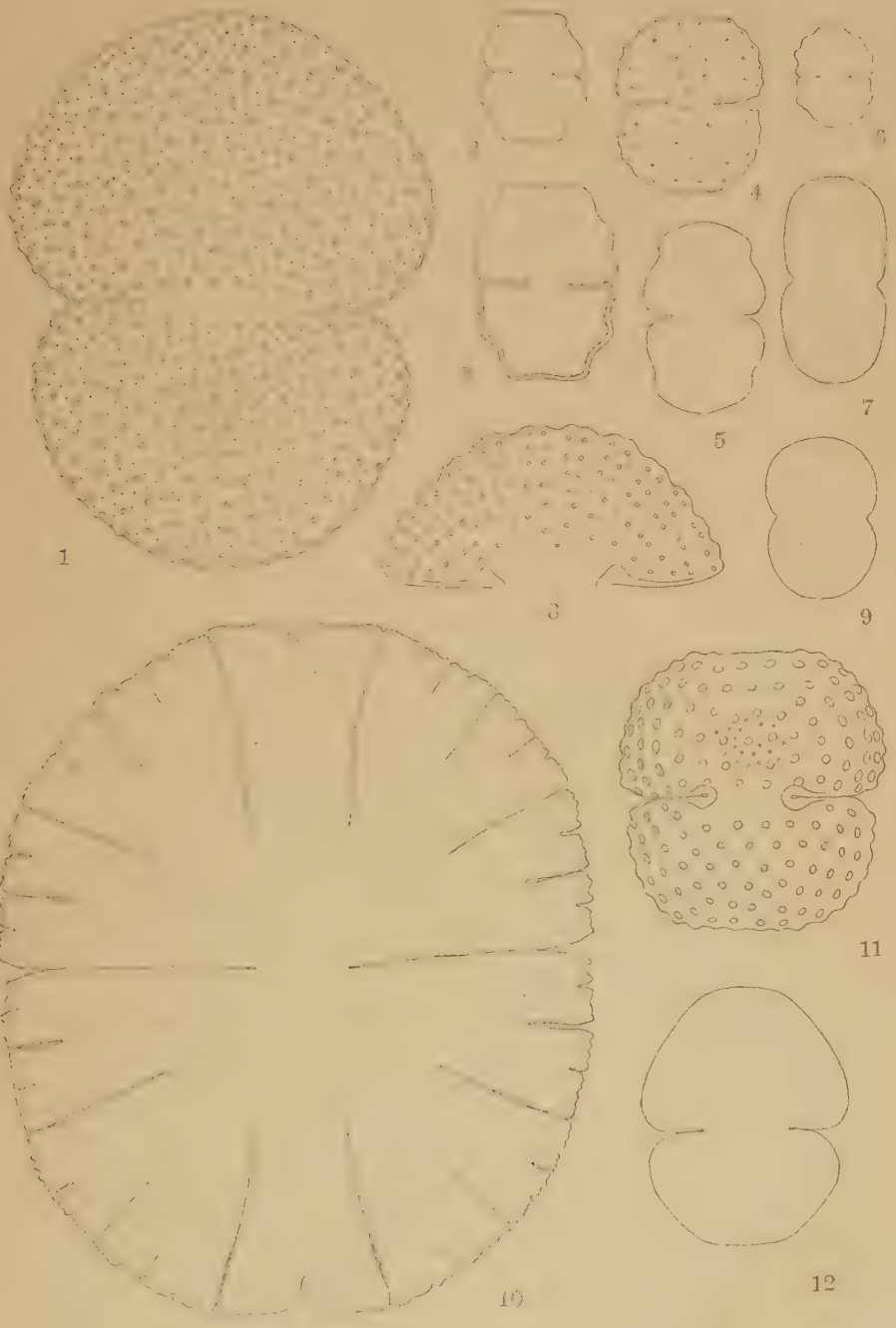

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Plate XXVII

Figs		*Page*
1.	*Cosmarium Portianum* Arch. var. *nephroideum* Wittr. ×600	170
2.	*Cosmarium Portianum* Arch. ×600	169
3.	*Cosmarium subcrenatum* Hantzsch. ×600 (*form.*)	172
4.	*Cosmarium nasutum* Nordst. forma *granulata* Nordst. ×600	168
5.	*Cosmarium ochthodes* Nordst. ×600	169
6, 6′.	*Cosmarium quadrifarium* Lund. forma *hexasticha* (Lund.) Nordst. (6, vertical view) ×600	171
7.	*Cosmarium reniforme* (Ralfs) Arch. ×600	171
8.	*Cosmarium contractum* Kirchn. var. *ellipsoideum* (Elfv.) W. & G. S. West. ×600	164
9.	*Cosmarium punctulatum* Bréb. var. *subpunctulatum* (Nordst.) Börg. ×600 (*small form*)	170
10.	*Cosmarium formosulum* Hoff. var. *Nathorstii* (Boldt) W. & G. S. West. ×600	165
11.	*Cosmarium Nymannianum* Grun. ×600	169
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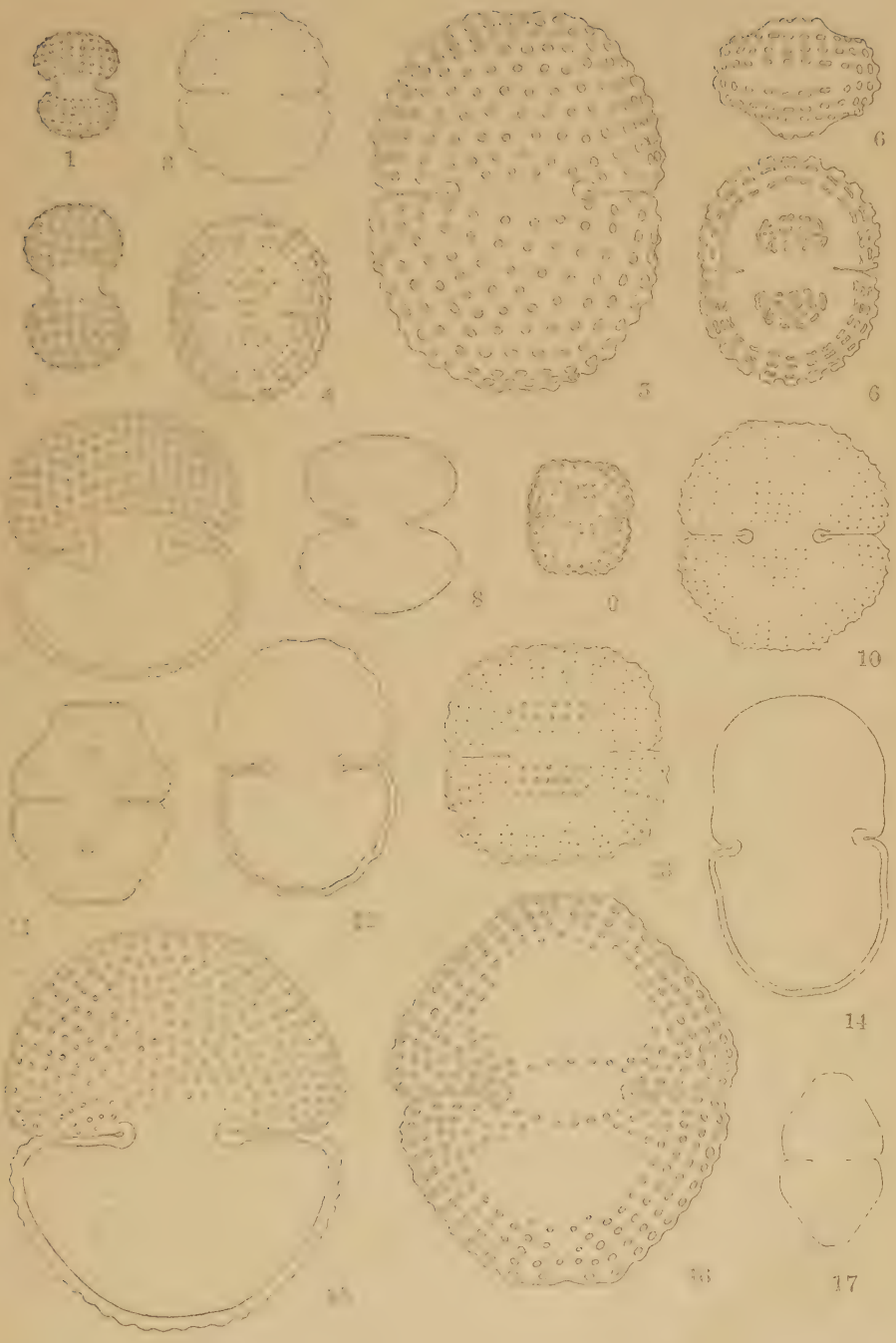

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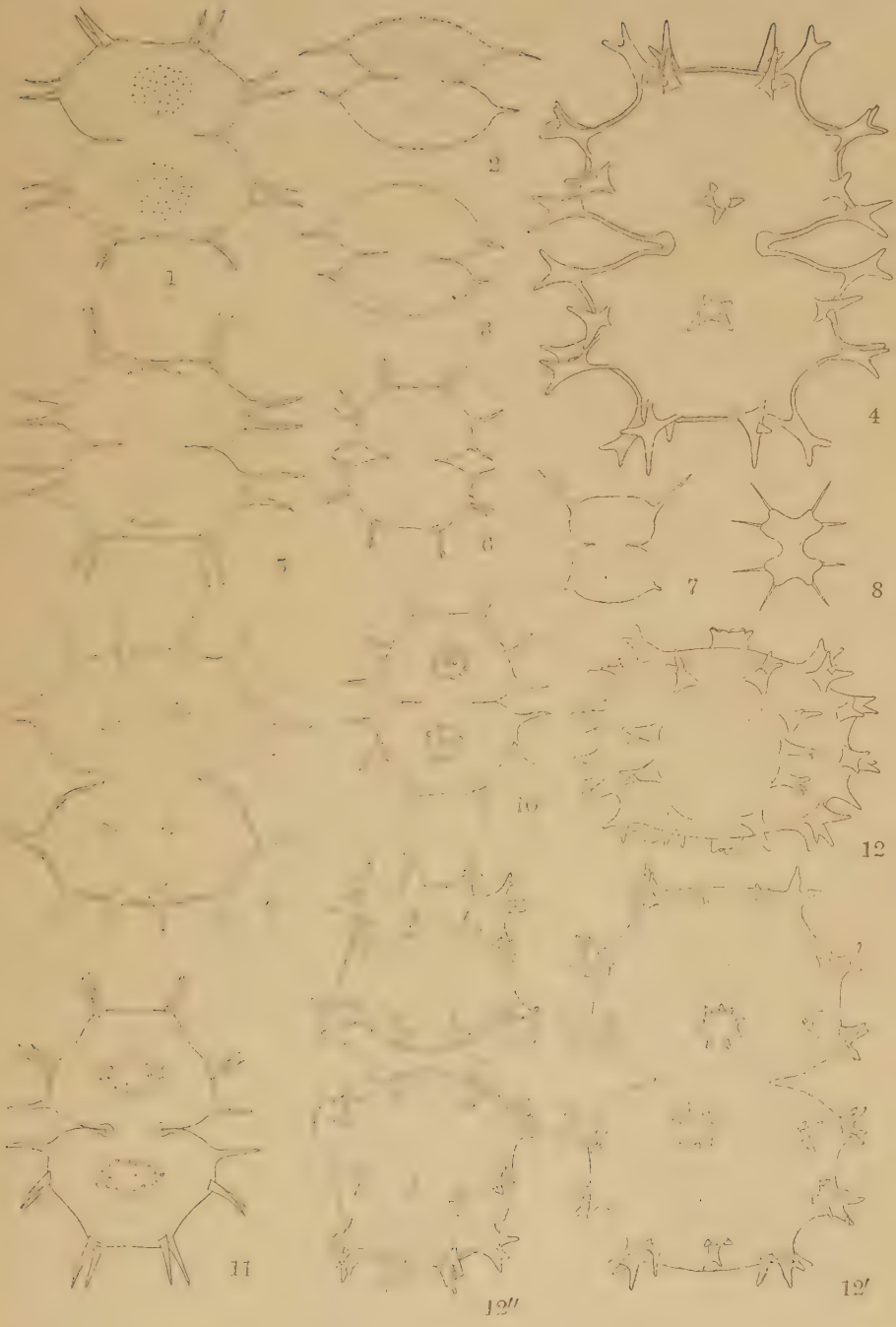

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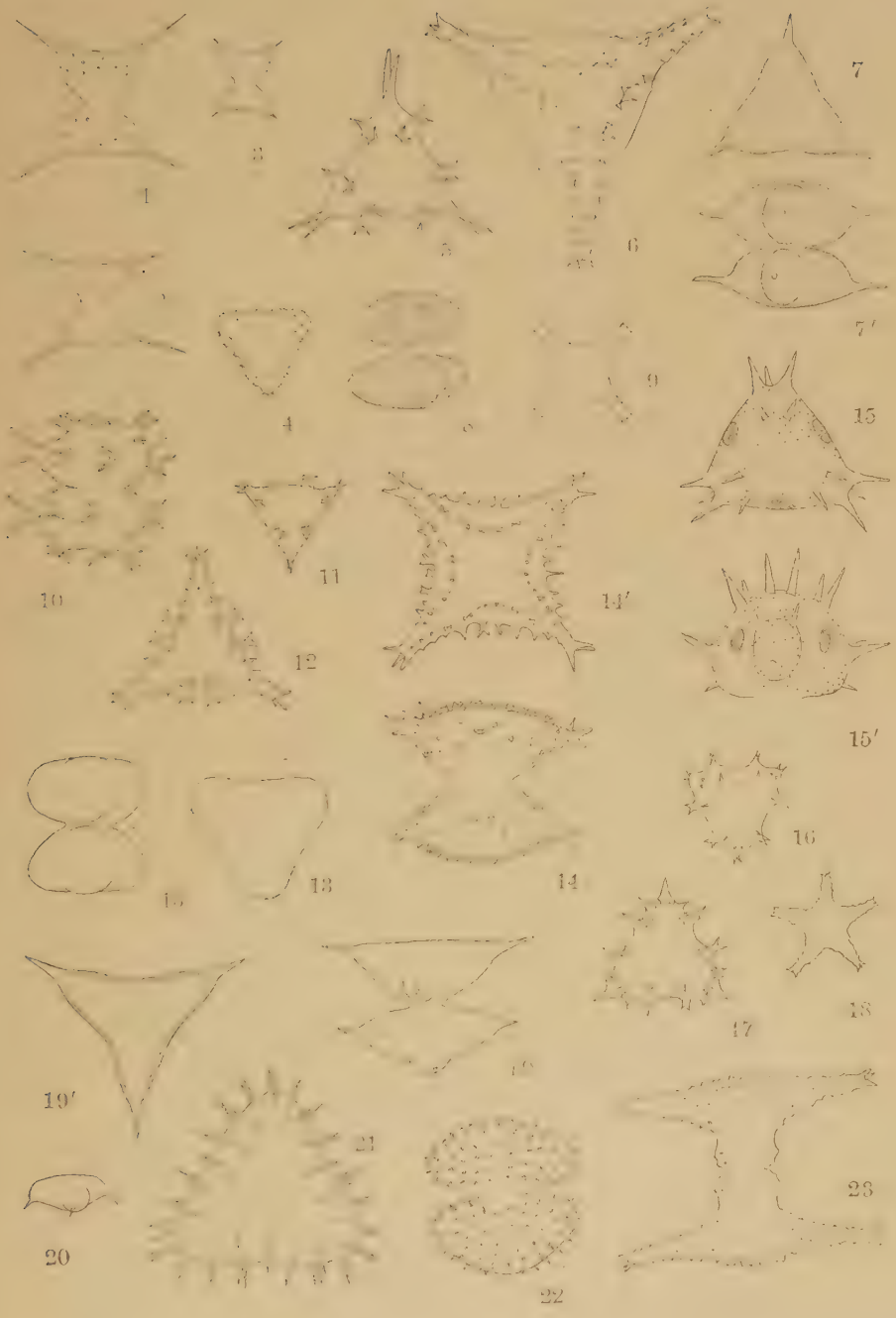

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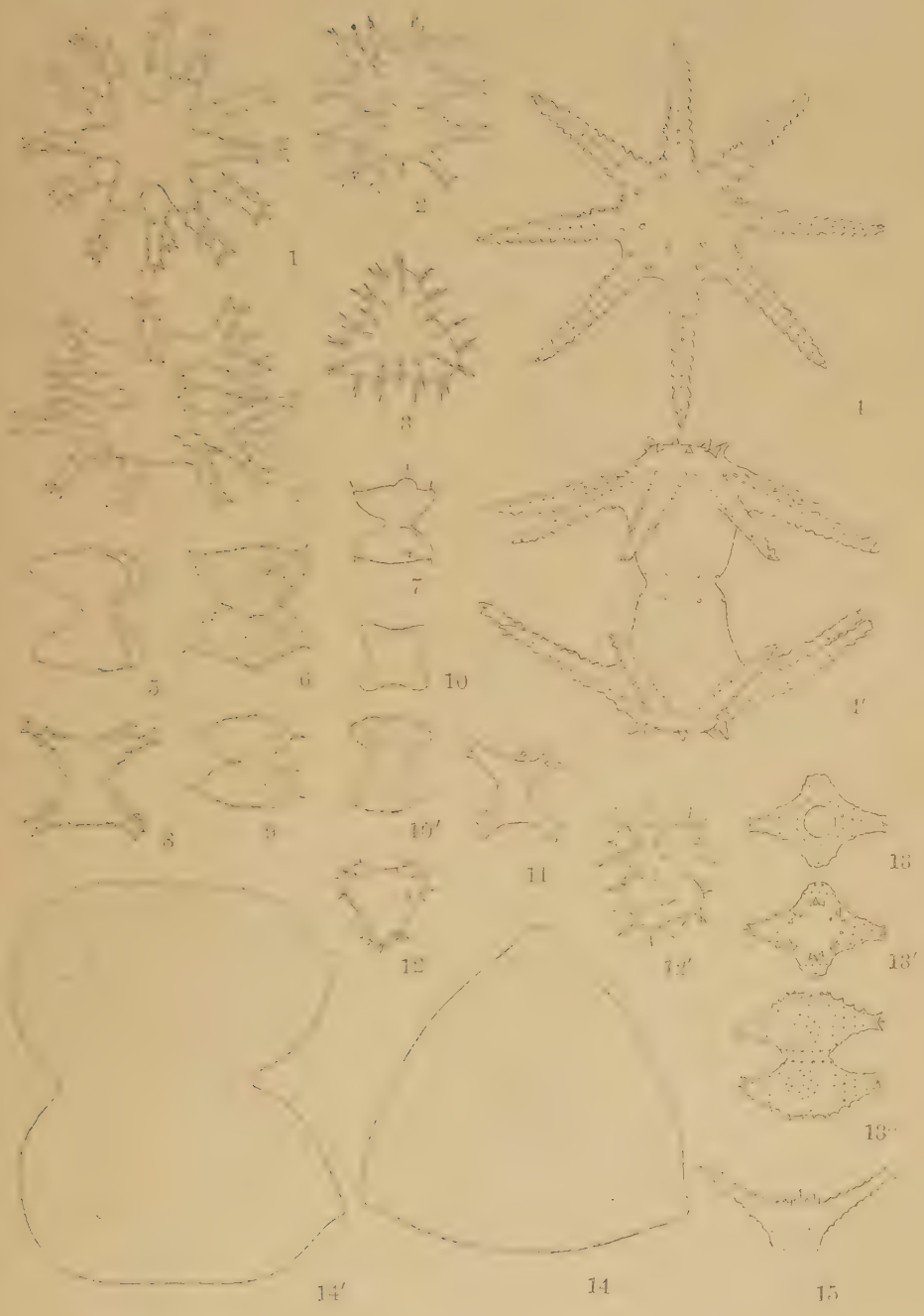
PL. XXX.



Yoshi K. Okada, *del.*

PL. XXXI.

Yoshi K. Okada, *del.*

Studies on the Scorpaenoid Fishes of Japan.

I. Descriptions of One New Genus and Five New Species.[1]

Kiyomatsu Matsubara

(Received Jul. 2nd, 1934)

The Scorpaenoid fishes embrace a great number of genera and species, the majority of which are of much commercial value in Japan. And yet the taxonomy of the group is very imperfect and much confusion is met with in their nomenclature. With a view to laying the classification of the fishes in question on a sounder basis a study of their external and internal characters was undertaken under the supervision of Professor A. Terao. The present paper forms the first instalment of a series of papers on this subject and deals with briefly a new genus and five new species. The author wishes to take this opportunity of expressing his warmest gratitude to Professor A. Terao for his kindness extended in various ways. He is also greatly indebted to Dr. Y. Wakiya for his valuable advices and criticisms and to the staff of the Tyôsen Fisheries Experimental Station for a loan of many specimens.

In the following description the body length is measured from tip of snout to base of caudal fin. The length of head is the oblique length from tip of snout to the end of upper opercular spine. The length of snout is also oblique length between tip of upper jaw and the anterior edge of orbit.

Hozukius[2], gen. nov.

External: Body rather robust and somewhat compressed. Maxillary and mandible covered with small ctenoid scales but not on branchiostegals.

---

1) Contributions from the Zoological Laboratory, Imperial Fisheries Institute, No. 34. The present work has been aided by a grant of a research fund from "Nihon Gakujutsu Shinkôkai" (Foundation for the Promotion of Scientific and Industrial Research of Japan).

2) Formed from Japanese name "Hôzuki".

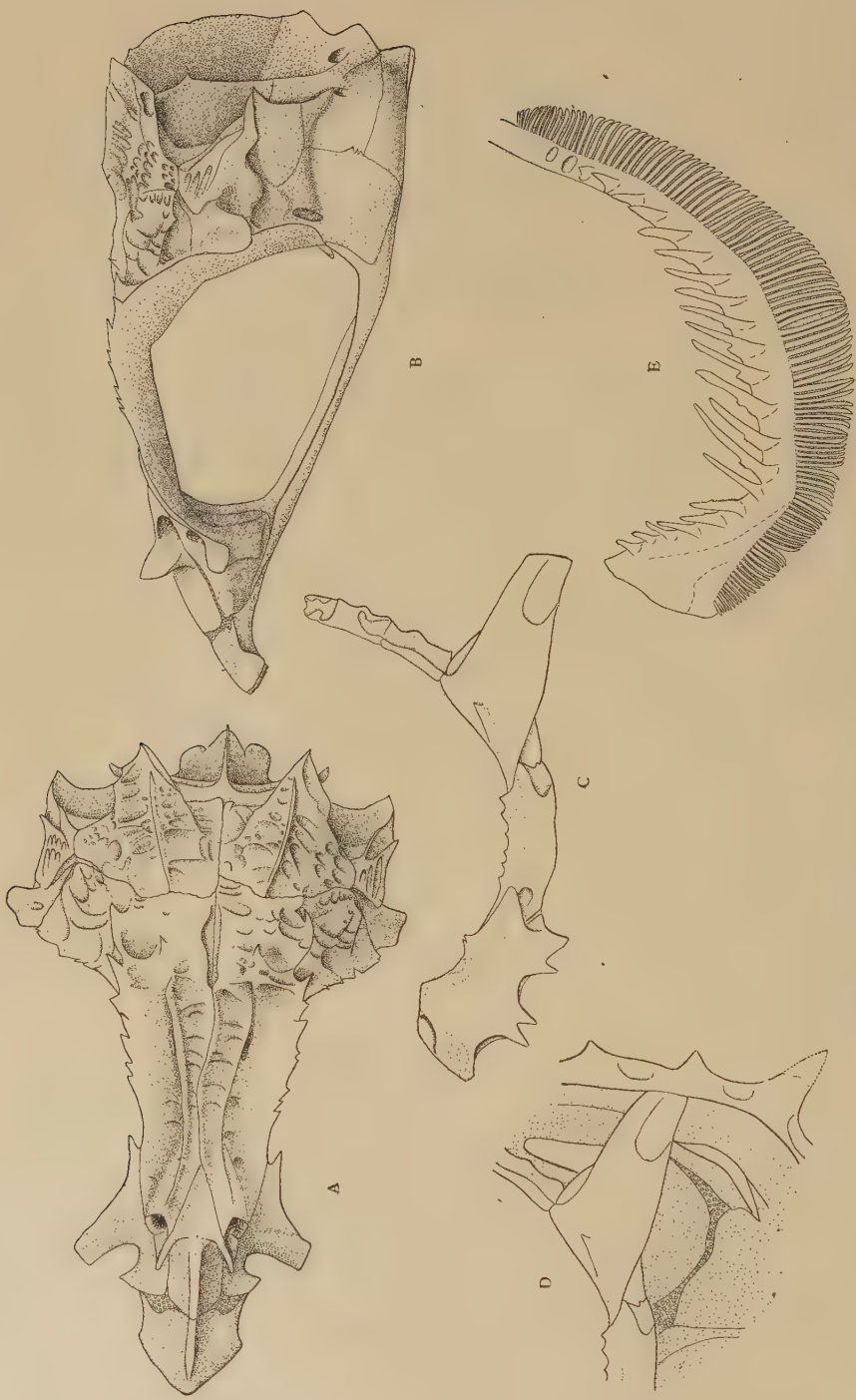


Fig. 1. *Hozukius embremarius* (Jordan and Starks) ×1½.
A, *B*, cranium; *C*, *D*, orbital bones; *E*, first gill-arch.

Teeth in villiform bands on jaws, vomer and palatines. Head much spinous; nasal, preocular, supraocular, postocular, tympanic, coronal, parietal, and nuchal spines present; upper and posterior margins of orbit provided with many accessory spines; parietal ridge not conspicuous. Orbital margins of preorbital and second suborbital bones armed with a sharp spine which is directed backward; first suborbital margined with several small spines; lower border of preorbital with two very strong, sharp bifid spines. Lower three preopercular spines much larger than upper two; subopercle and interopercle each with a small, sharp spine at their approximation. Symphyseal knob very large. Dorsal with 12 spines and about 12 rays; anal with 3 spines and about 6 rays. Axillary flap absent.

Internal: Skull thick and heavy. Base of skull (parasphenoid) moderately curved. Frontal, parietal, pterotic and supratemporal much cavernous, resembling a bee-hive in general appearance. Parietals entirely meeting; upper margin of orbit and frontal ridges somewhat raised. Mesethmoid processes directed upward and forward. Nodule on the front of prefrontal for the articulation with palatine well developed. Ventral process of basisphenoid rudimentary, not reaching to parasphenoid; basisphenoid with a small pore between it and basis cranii. Myodome well developed, with a rather large posterior opening. Second suborbital bone very broad and long, entirely touching to the upper ridge of preopercle; third and fourth suborbital bones present. Gill-rakers long and stout, the longest one much longer than the longest gill-lamella. Vertebrae $9+16+$hypural$=26$; parapophysis developed from the sixth vertebra, its processes widely diverging, directed outward and downward. Air bladder absent. Peritoneum jet black.

Type species:—*H. embremarius* (Jordan & Starks).

In 1895 Goode and Bean[1] erected a genus, *Helicolenus*, for the reception of *Scorpaena dactyloptera* De La Roche from the Mediterranean. Jordan and Starks[2] referred in 1904 two species of fishes from Japan to the genus *Helicolenus*, viz., *H. embremarius* Jordan and Starks and *H. dactylopterus* (De La Roche). These two species are also represented

1) Good and Bean, 1895. Oceanic Ichthyology, p. 248.

2) Jordan and Starks, 1904. A review of the Scorpaenoid fishes of Japan. Proc. U. S. Nat. Mus., 27, p. 127.

Fig. 2. Lower jaw and palate of *Helicolenus dactylopterus* (De La Roche) ×1½

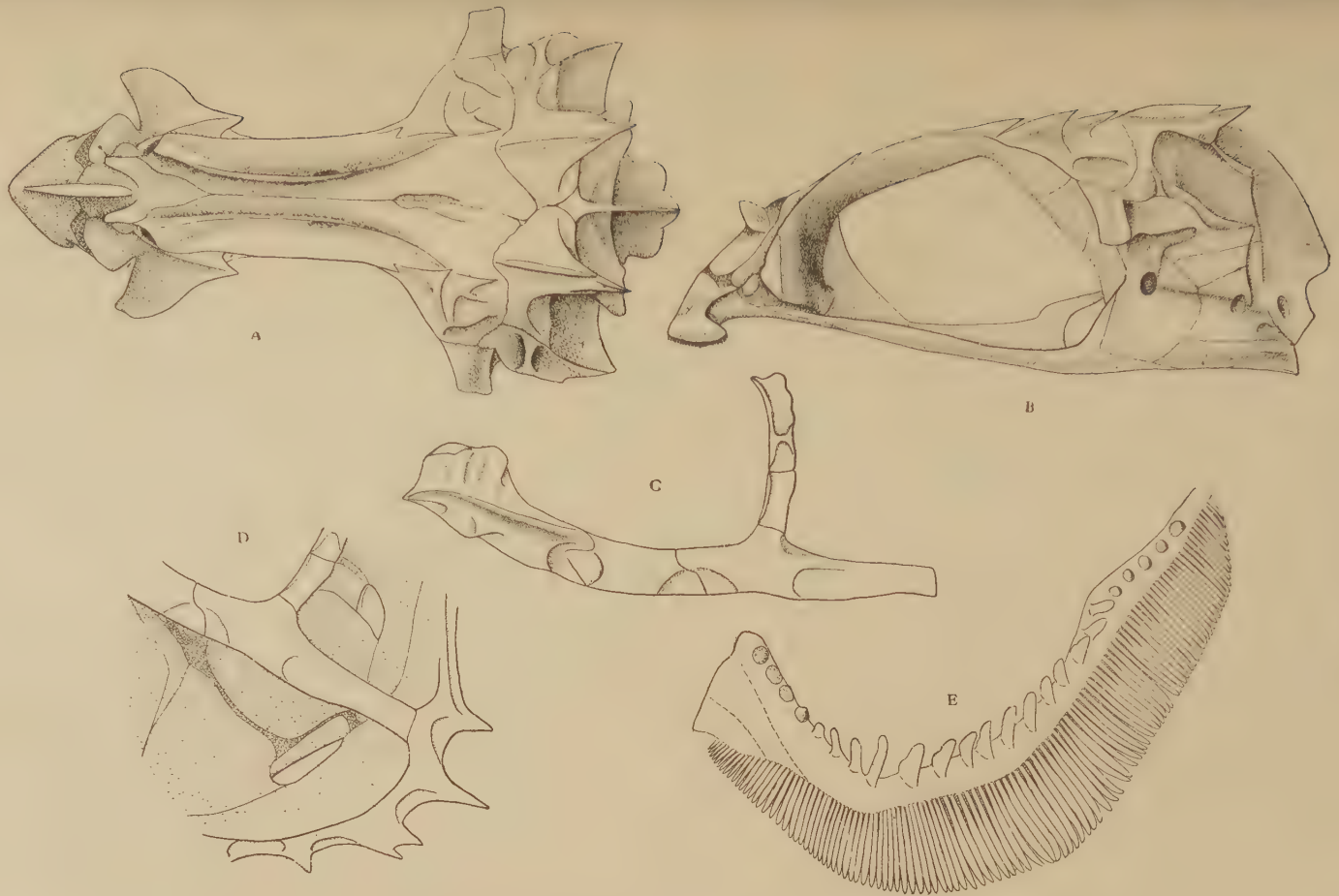


Fig. 3. *Helicolenus dactylopterus* (De La Roche) ×1½.
A, B, cranium; *C, D*, orbital bones; *E*, first gill-arch.

Fig. 4. Lower jaw and palate of *Hozukius embremarius* (Jordan and Starks) × 1½

in my material, but found quite distinct from each other in the internal characters which should go as generic criteria. Hence the creation of the new genus *Hozukius* which is based on *Helicolenus embremarius* of Jordan and Starks.

The differences between the two genera may be given as follows :—

Hozukius	*Helicolenus*
1. Base of skull moderately curved.	1.....nearly straight.
2. Frontal, parietal, pterotic and supratemporal much cavernous, resembling a bee-hive in general appearance.	2.....entirely smooth.
3. Ventral process of basisphenoid rudimentary, not reaching to parasphenoid.	3.....much developed, entirely touching to parasphenoid.
4. Upper and posterior margins of orbit with many sharp accessory spines.	4.....without accessory spine.
5. Coronal spines sharp.	5.....absent.
6. Orbital margins of preorbital and second suborbital each with a sharp spine which is directed backward, and also several smaller ones on the first suborbital.	6.....entirely smooth.
7. Lower margin of preorbital with two large bifid spines.	7.....smooth.
8. Preorbital without ridge.	8.....with a rather sharp longitudinal ridge.
9. Lower three preopercular spines larger than the upper two.	9.....second one the largest.
10. Subopercle and interopercle each with a sharp spine at their approximation.	10.....entirely smooth.
11. Gill-rakers rather long, much longer than the longest gill-lamella.	11.....short and tubercular, about half the length of the longest gill-lamella.
12. Axillary flap absent.	12.....upper angle of axil with a large cutaneous flap.

It may be mentioned that *Hozukius* is very closely related to the subgenus *Zalopyr* of the genus *Sebastodes* (including *S. aleutianus* and *S. matsubarae*) whereas *Helicolenus* to the subgenus *Pteropodus* or its allies of the genus *Sebastichthys* (including *S. nivosus*, *S. pachycephalus*, *S. elegans*, etc.), so that these two genera appear to be of different origins. With the second suborbital bone much developed and rigidly connected with the upper ridge of preopercle as they are, the two genera in question are much more specialized than either *Zalopyr* or *Pteropodus* in their organization.

Sebastodes (*Primospina*) *wakiyai*, sp. nov.

New Japanese Name: Gaya-modoki.

Head 3.21 in body length; depth 3.0. Eye 3.39 in head, snout 3.93; postorbital part of head 2.10; interorbital space 3.93; longest

dorsal spine 2.04; next to last dorsal spine 3.17; last spine also 3.17, second anal spine 2.09; third spine 2.14. Dorsal XIII, 14; anal III, 7; pores of lateral line 30. Gill-rakers 11+27, very long, the longest one 1.54 in eye.

Body very slender and head short. Mouth not large, maxillary reaches to below center of eye. Lower jaw projecting when mouth is closed and with a small symphyseal knob. Teeth small, set in rather narrow bands, wide on front of upper jaw. Interorbital space convex, its width less than diameter of orbit, ridges entirely obsolete on head; nasal spines moderate; preocular spine rudimentary and other cranial spines entirely absent; preorbital also without spines; subopercle and interopercle each with a small spine at their approximation. Maxillary, mandible, sonout and branchiostegal rays with minute scales. Peritoneum jet black. Color in formalin dark brown above paler below and no peculiar markings. Described from a male specimen, 225 mm. in total length from Miyako, near Morioka, Prov. Rikutyû.

Very near to *S. taczanowskii* (Steindachner), but differs from it in having smaller number of pores on lateral line (30 instead of 45), small scales on mandible and branchiostegal rays, and last two dorsal spines just equal in length. Allied to *S. steindachneri* of Jordan and Starks (not of Hilgendorf), but easily distinguished from it in having the preocular spine, small scales on mandible, slenderer body, last two dorsal spines equal in length and body dark brown without markings.

Sebastodes (*Zalopyr*) *melanostictus*, sp. nov.

New Japanese Name: Goma-akô.

Head 2.77 in body length; depth 2.90. Eye 4.4 in head; interorbital space also 4.4; snout 3.58; postorbital part of head 2.0; longest dorsal spine (fourth spine) 2.69; next to last spine 6.0; last spine 4.34. Dorsal XIII, 14; anal III, 7; pores of lateral line 31; gill-rakers 9+23, the second one on lower limb 1.71 in eye.

Lower jaw much projecting beyond the upper and with a conspicuous symphyseal knob; snout longer than eye, 1.23 times of latter; postorbital part longer than twice the length of orbit. Teeth set in three rows at sides of lower jaw, sharp, much wider anteriorly; teeth of upper jaw arranged in very broad bands at sides, twice as

broad as lower ones, becoming wider anteriorly; vomer and palatines with moderate bands of teeth; frontal and parietal ridges low; cranial spines very low but stout; nasal, preocular, supraocular, postocular, tympanic, parietal, coronal and nuchal spines present; two short spines before as well as below eye; preorbital with three lobes, the two anterior broadly rounded without spine but the one posterior angulated with four small spines. Peritoneum and mouth dusky. Red in life. But color in formalin somewhat grayish above, whitish below; body and fins vaguely blotched and specked with dark spots; three dark bars radiating from eye; top of head with three dark cross bands. Length 507 mm; from Prov. Kazusa.

Resembles American species *S. aleutianus*, but differs from it in having peritoneum black, pores of lateral line 38, longest dorsal spine about $2\frac{1}{2}$ in head, snout much longer than eye or than width of interorbital space, and body specked with dark spots.

Sebastodes (*Zalopyr*) *kawaradae*, sp. nov.

New Japanese Name: Kawarada-akô.

Head 2.63 in body length; depth 2.82. Eye 3.74 in head; snout 3.89; postorbital part of head 2.01; interorbital space 4.44; longest dorsal spine 2.59; next to last spine 5.32; last spine 3.94; second anal spine 3.30; third anal spine 2.94. Dorsal XIII, 14; anal III, 7; pores of lateral line 34. Gill-rakers 10+22, long and slender, the longest one half the length of orbit.

Snout slightly shorter than orbit; lower jaw much projecting when mouth is closed and with a large symphyseal knob. Teeth small, in broad bands on jaws, vomer and palatines; the bands of upper jaw wider than those of lower jaw and wide in front of premaxillaries. Interorbital space narrower than diameter of orbit; postorbital part of head rather long, 1.86 times of diameter of orbit; frontal ridges scarcely visible without dissection; parietal ridges low but sharp; nasal, preocular, supraocular, postocular, tympanic, coronal, parietal and nuchal spines present, all these spines very low but stout except coronal which is very weak and sharp; five small spines arranged in a row below the orbit; preorbital with three lobes, the posterior two angulated but without spines; interopercle and subopercle each with a spine at their junction. Dorsal spines rather high, the last spine

much longer than the penultimate one; second anal spine also shorter than third. Fins covered with small ctenoid scales nearly to their tips. Peritoneum silvery. Color in formalin dark brown above, paler below, top of head with three dark cross bands; two dark bands radiating from eye, of which the lower one runs across cheek and the upper one goes up to upper angle of preopercle. Described from a male specimen, 455 mm in total length, from off Miyako, near Morioka.

Bears resemblance to *S. melanostictus*, but differs from it in the following points: peritoneum silvery, but not black; eye longer than width of interorbital space or length of snout; five small spines arranged in a row below the eye; pores of lateral line 34; color dark brown without dark spots on body or fins. The present species is allied to *S. matsubarae* (Hilgendorf) but differs from it in the following points: preorbital without spines (in *S. matsubarae* with two large and pungent spines); five spines arranged in a row below eye (in *S. matsubarae* with two large spine, one before and the other below eye); eye small, 1.86 in postorbital part of head (1.5 in *S. matsubarae*); peritoneum silvery (jet black in *S. matsubarae*). It also differs from its allied species, *S. baramenuke* Wakiya, in having five spines below eye (absent in *S. baramenuke*); preorbital without spine (in *S. baramenuke* with two large spines and posterior one forked); eye small, 3.74 in head (3.3 in *S. baramenuke*); color dark brown and peritoneum silvery (in *S. baramenuke* body red and peritoneum jet black).

Sebastichthys (*Pteropodus*) *latus*, sp. nov.

New Japanese Name: Kawari-murasoi.

Head 2.39 in body length; depth 2.26. Eye 4.16 in head; snout 3.89; interorbital space 6.48; longest dorsal spine (6th spine) 2.43; next to last spine 3.24; last spine 3.15, second anal spine 2.35. Dorsal XIII, 13; anal III, 6; pores of lateral line 34. Gill-rakers very short, 8+16, the longest one 4.67 in eye.

Body very deep; lower jaw included when mouth is closed; mouth very large, maxillary a litte passing under posterior margin of orbit. Teeth small, in broad bands on jaws, wide on front premaxillaries; narrow on vomer and palatines. Interorbital space very narrow and supraocular margins much elevated, between which there forms a deep and flat area, covered with small scales; frontal ridges not visible

without dissection. Cranial ridges and spines well developed; nasal, preocular, postocular, tympanic and parietal spines present; supraocular spines entirely absent. Preorbital with two angulated lobes, the posterior one forming a small spine. Dorsal spines rather low, the last two spines equal in length; pectoral composed of 19 rays, the lower 12 rays thick and unbranched, the longest one extends to above insertion of anal fin. Snout, jaws and branchiostegals entirely naked. Parietal bones, widely separated. Color in formalin dark brown, head darker; body with three diffuse cross bands, first at shoulder, second under spinous dorsal, third under soft dorsal which extends to caudal peduncle; fins and lower side of head scattered with round dark spots, which are fewer on throat; three dark bands radiating from eye, of which one to cheek and others to opercle. Described from a female specimen 174 mm in total length, collected by Mr. Shigeo Masuda from Tokyo fish-market, probably from Tokyo Bay.

The species differs from *S. pachycephalus* (T. & S.) in having much deeper body, the last two dorsal spines equal in length, and in other details.

Sebastichthys (*Pteropodus*) *longispinis*, sp. nov.

New Japanese Name: Kôrai-yoroi.

Head 2.60 in body length; depth 2.65. Eye 3.37 in head; snout 4.06; interorbital space 7.6; longest dorsal spine 2.11; second anal spine 1.75. Dorsal XIII, 12; anal III, 6; pores of lateral line 26. Gill-rakers on first arch 6+10, the longest one 5.0 in eye.

Lower jaw a little shorter than upper, and the symphyseal knob not visible; maxillary extends to below posterior orbital rim. Teeth very small, in moderate bands on jaws, vomer and palatines. Interorbital space deeply concave and supraorbital margins very high; a pair of remarkable frontal ridges run near middle of interorbital, forming a very narrow deep canal. Head strongly armed; nasal, preocular, postocular, tympanic and parietal spines present; supraocular spines entirely obsolete. Preorbital with two angles, each ending in a sharp spine. Dorsal spines invariably 13, very long, nearly equal to half the length of head; second anal spine also very long, much longer than half the length of head. Pectoral slightly past vent, the lower eight rays thick. Maxillary, preorbital, snout, interorbital, mandible, bran-

chiostegals entirely naked. Parietals meeting. Color in formalin light grayish brown with three diffuse dark cross bands; two broad dark bands radiating from eye; interorbital with two broad cross bands; anterior half of caudal fin entirely whitish, the posterior half dark with three irregularly arranged cross bands. Described from a male specimen 149 mm in length, obtained by the writer from Huzan, Tyôsen; many other specimens were secured from that locality.

The present species is near to *S. elegans* of Jordan and Starks (not of Steindachner and Döderlein), but separable from it in the following characters: parietals entirely meeting (separated in *S. elegans* of Jordan and Starks); second anal spines very long, much longer than half the length of head; longest dorsal spines also very long, nearly equal to half the length of head; anterior half of caudal entirely whitish; dorsal spines invariably 13 (always 14 in *S. elegans* of Jordan and Starks).

Descriptions of Two New Fishes from Kominato, Prov. Bôsyû.[1]

Ken-ichi Ebina

(Received Sep. 3rd., 1934)

A collection of tide-pool fishes was made in August, 1932 at Kominato, Prov. Bôsyû, including two new species, *Apogon kominatoensis* and *Clariger papillosus* which are described in the present paper.

The author is greatly indebted to Professor Dr. Arata Terao for his kind supervision during the course of his study, and his hearty thanks are also due to Mr. K. Matsubara for assistance kindly given in various ways.

Apogon kominatoensis, n. sp.

(New Japanese Name: Kominato-tenzikudai)

Depth $2\frac{2}{3}$ in body length, head $2\frac{1}{2}$, width $1\frac{7}{10}$; snout 5 in head from tip of snout; eye $3\frac{1}{3}$, much longer than snout; maxillary reaches opposite hind eye edge, expansion 2 in eye, length $1\frac{9}{10}$ in head; teeth villiform, in band on jaws, vomer and palatines; interorbital $5\frac{1}{10}$ in head; infraorbital and postorbital not serrate, preopercle denticulated. Gill-rakers 4+12, of which 5 are rudiments, longest gill-raker $3\frac{1}{2}$ in eye. Scales 24 in lateral line to caudal base and 3 more on latter; 2 above 7 below, 6 predorsal, 2 rows on cheeks; head naked except cheeks and opercles. Scales of lateral line with 9 to 12 basal radiating striae, and 90–110 apical denticles arranged in 2 or 3 transverse series. Dorsal fin VI, I+9, second dorsal spine $2\frac{1}{3}$ in head length, first ray 2; anal fin II, 8; second anal spine 4 in head length. Caudal fin forked; least depth of caudal peduncle $2\frac{4}{5}$ in head.

1) Contributions from the Zoological Laboratory, Imperial Fisheries Institute, No. 35.

Colour in life brownish red, lighter below, fins all uniform light red. Side of head and body sprinkled with numerous small brownish dots, not forming bands or blotches.

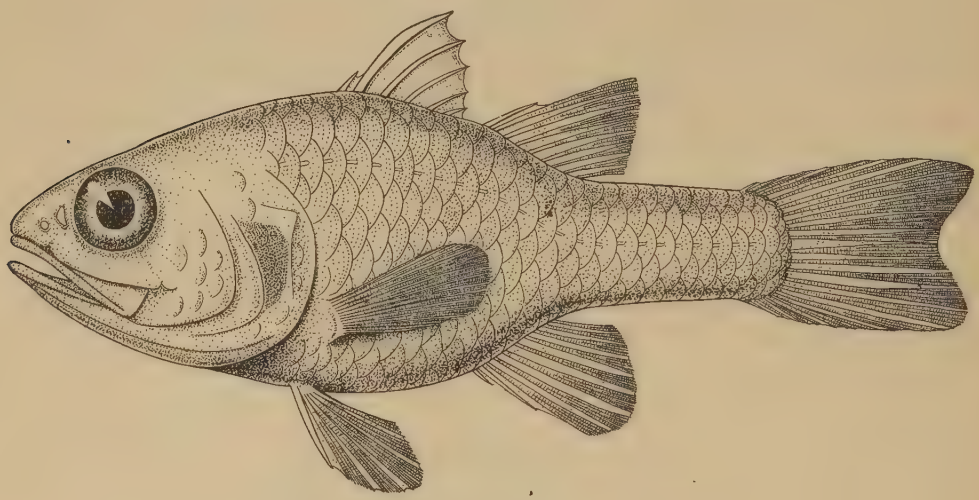


Fig. 1. *Apogon kominatoensis*, n. sp. ×2

Three speciemens were collected in tide-pools at Kominato, their measurments being given in Table 1. Type speciemen (No. 1) is preserved in the Zoological Laboratory, Imperial Fisheries Institute, Tokyo.

This species is closely allied to *Apogon cardinalis* Seal,[1), 2)] *A. unicolor* Döderlein,[3)] and *A. erythrinus* Snyder,[4)] but differs from these in several characters as shown in the following Table 2.

---

1) The fishes of the Families Amiidae, Chandidae, Duleidae, and Serranidae, obtained by the U. S. Burean of Fisheries steamer "Albatross" in 1907 to 1910, chiefly in the Phillipine Islands and adjacent seas. U. S. Nat. Mus. Bull. 100 (10) p. 102.

2) Amia cardinalis Seal. Phillipine Jour. Sci., 4 No. 6, 1909, p. 509.

3) List of fishes collected in 1883 and 1885 by Pierre Louis Jouy and preserved in the U. S. Nat. Museum, with descriptions of six new species. Proc. U. S. Nat. Mus. 23 p. 749.

4) A catalogue of the shore fishes collected by the steamer "Albatross" about the Hawaiian Island in 1902. Bull. U. S. Comm., 22 p. 526.

Table 1.

	Sp. No. 1 (type)	No. 2	No. 3
Total length	64 mm	64 mm	58 mm
Sex	male	male	male
Scales	$24\frac{3}{7}$	$24\frac{3}{7}$	$23\frac{2}{7}$
Dorsal fin	VI, I, 9	VI, I, 9	VI, I, 9
Anal fin	II, 8	II, 8	II, 8
Gill-raker	4+12	4+12	4+12
Body length	49	49	46
Depth	18	18	17
Width	11	11	11
Head	20	20	18
Eye	6	6	$5\frac{9}{10}$
Snout	4	4	4
Body length/depth	$2\frac{2}{9}$	$2\frac{2}{9}$	$2\frac{3}{4}$
Body length/head	$2\frac{1}{2}$	$2\frac{1}{2}$	$2\frac{5}{9}$
Head/eye	$3\frac{1}{3}$	$3\frac{1}{3}$	3
Head/snout	5	5	$4\frac{1}{2}$
Head/width	$1\frac{4}{5}$	$1\frac{4}{5}$	$1\frac{3}{5}$
2nd dorsal spine	$8\frac{1}{2}$	$8\frac{1}{2}$	$8\frac{1}{8}$
2nd anal spine	5	5	5

Table 2.

	kominatoensis	*unicolor*	*cardinalis*	*erythrinus*
Body length/head	$2\frac{2}{5}$	$2\frac{2}{5}$	$2\frac{2}{5}-2\frac{1}{2}$	$2\frac{3}{5}$
Body length/depth	$2\frac{2}{9}$	$2\frac{5}{6}$	$2\frac{3}{4}-2\frac{7}{8}$	$2\frac{1}{2}$
Head/eye	$3-3\frac{1}{3}$	$3\frac{1}{6}$	$3-3\frac{1}{4}$	$2\frac{7}{10}$
Head/snout	$4\frac{1}{2}-5$	$3\frac{3}{8}$	$4\frac{1}{2}-5$	$4\frac{4}{5}$
Head/width	$1\frac{2}{5}-1\frac{4}{5}$	—	$2-2\frac{1}{8}$	$2\frac{1}{2}$
Scales of lateral line	$23-24\frac{3}{7}$	$24\frac{3}{8}$	$23-24\frac{2}{6}$	$26\frac{3}{7}$
Gill-rakers	4+12	5+13	5+14	—
Head/2nd dorsal spine	$2\frac{1}{3}$	$2\frac{2}{5}$	$1\frac{7}{8}-2$	$1\frac{3}{5}$
Head/2nd anal spine	$3\frac{1}{3}$	$3\frac{1}{2}$	$2\frac{2}{3}-3$	$3\frac{3}{4}$
Head/maxillary	$2\frac{1}{10}$	$1\frac{4}{5}$	—	$2\frac{1}{5}$
Supraorbital	not serrate	serrate	serrate	not serrate
Postorbital and infraorbital	not serrate	not serrate	serrate	not serrate

Clariger papillosus, n. sp.

(New Japanese Name:
Hige-sezirohaze)

Depth 7 in body length; head, as measured to end of opercular flap, $3\frac{4}{5}$ in length without caudal; depth of caudal peduncle 9; eye $9\frac{1}{6}$ in head, snout 5, interorbital space $5\frac{2}{5}$; dorsal III, 13; anal, 12; pectoral 17. Dorsal and ventral contours of body straight, body cylindrical anteriorly, much compressed behind. Head broad, almost equal to depth of body, considerably depressed, snout broad and blunt; lower jaw projecting, maxillary extending backward to a point beneath posterior of eye. Mouth cleft almost vertically directed anteriorly, but horizontally running posteriorly. Teeth very small, arranged in narrow band on both jaws.

The eyes directed obliquely upward; interorbital space flat, its length is about 1.5 times the diameter of eye. Gill clefts restricted to the sides, broader than the base of

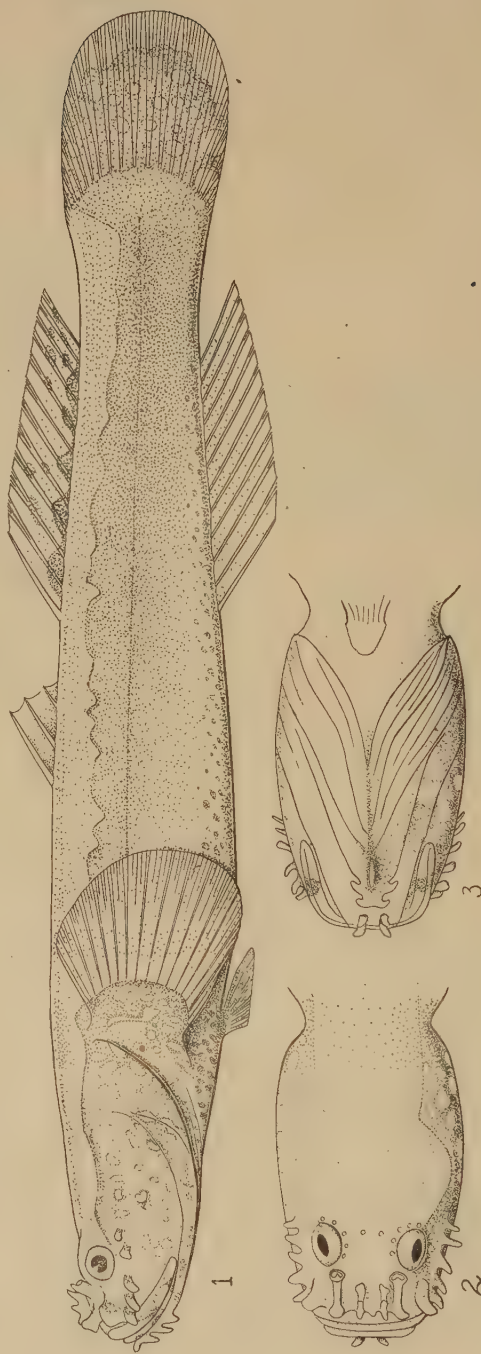


Fig. 2. *Clariger papillosus*, n. sp. ×5
1. Lateral view. 2. Dorsal view of head. 3. Ventral view of head.

Fig. 3. *C. sirahamaensis* Matsubara ×5
1. Dorsal view. 2. Ventral view.

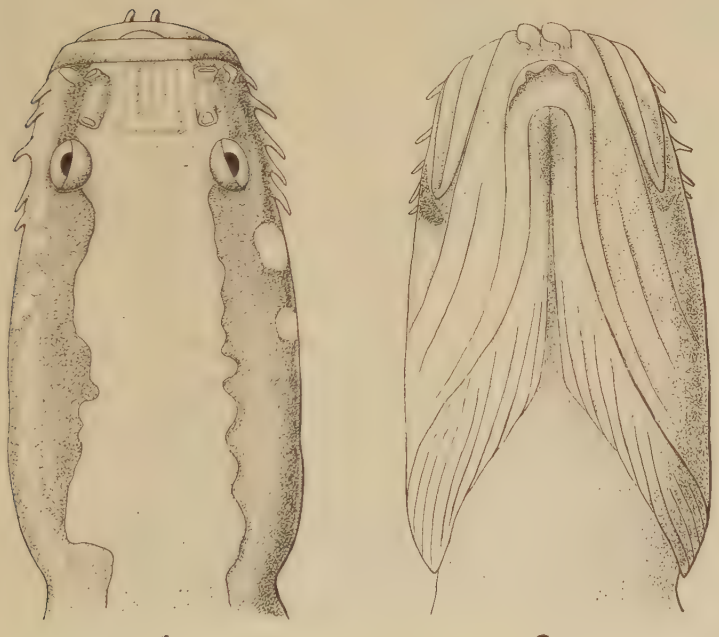


Fig. 4. *C. cosmurus* Jordan & Snyder ×5
1. Dorsal view. 2. Ventral view

pectorals. There are five fleshy papillous barbels below eye, large one before eye, a pair of broad barbels at the snout. Nasal canal tubular, its posterior pore very near the eye; a pair of barbels at the symphysis.

Head and body entirely naked. Dorsals separated, the first dorsal spine inserted about midway between snout and origin of the caudal fin; soft dorsal and anal with fleshy membranes; the base of second dorsal slightly longer than that of anal. Anal inserted below second

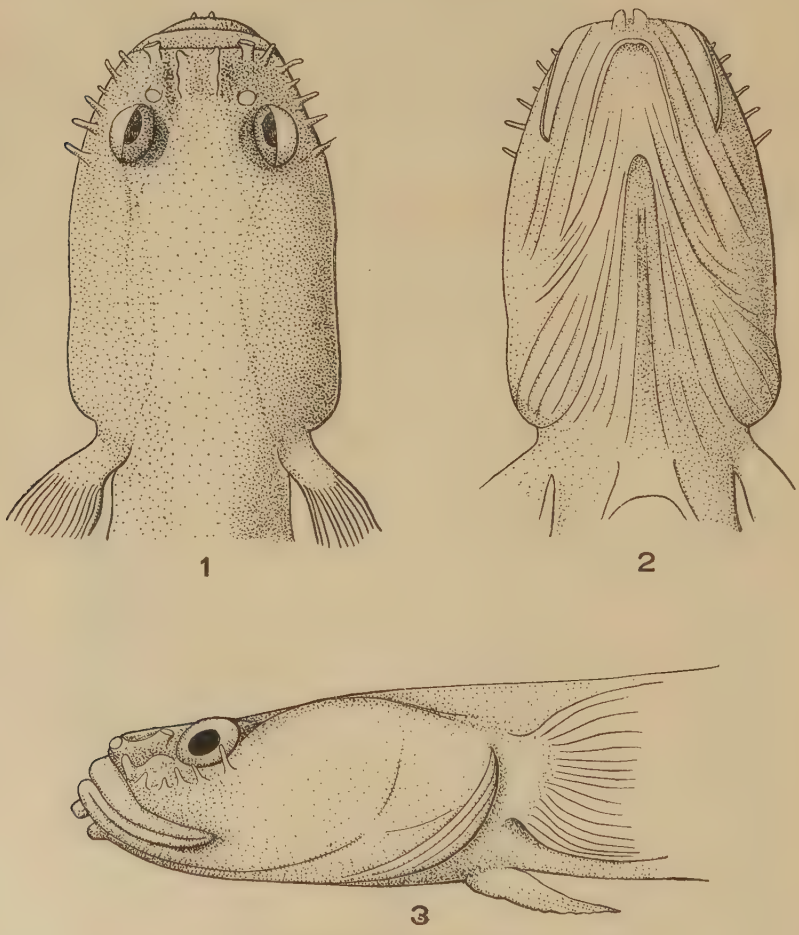


Fig. 5. Head of *Clariger exilis* Snyder ×5
1. Dorsal view. 2. Ventral view. 3. Lateral view.

soft dorsal rays. Pectorals and caudal rounded. Ventral united, free posteriorly.

Body grey, back and pectorals whitish; chins and caudal fin are mottled with small irregular white spots, abdomen black spots.

Based on a single male speciemen 25 mm long obtained from a gravelly tide-pool at Kominato and preserved as type in the Zoological Laboratory, Imperial Fisheries Institute, Tokyo.

Differs principally from the hitherto known three species[a)b)c)] of this genus by the following characters (Table 3).

Table 3.

	C. cosmurus (fig. 4)	*C. exilis* (fig. 5)	*C. sirahamaensis* (fig. 3)	*C. papillosus* (fig. 2)
Scales	cycloid scales in median part of caudal peduncle	scales extending forward beyond the base of 1st dorsal	wanting	wanting
Shape of body	slender, its depth $7\frac{3}{4}$ in length of body	very slender, its depth 8 in length of body	rather robust, its depth $6\frac{7}{10}$ in length	slender, its depth 7 in length
Width of interorbital space	narrow, about equal to the diameter of the eye	moderate, little longer than eye.	wide, more than twice as long as eye.	moderate, about one and half as long as eye.
Barbels below eye	present, small five barbels	prensent, small fleshy five barbels	absent	present, well developed five barbels
Colouration	pinkish light brown	pinkish light brown	dark grey	grey
Dorsal and anal fins	III-12; 12	III-11; 11	III-9; 9	III-12; 12

a) Jordan, D. S. & Snyder J. O. A review of the gobioid fishes of Japan with descriptions of twenty-one new species. Proc. U. S. Nat. Mus., 24, 1901, p. 121.

b) Snyder, J. O. Descriptions of new genera and species of fishes from Japan and the Riu Kiu Island. Ibid. 40 1911, p. 544.

c) Sakamoto, K. On a collection of tide-pool fishes from Prov. Bôsyû, with a description of one new species. This Journal, 27 (1), 1932, p. 7.

Larvae and Young of Fishes found in the Vicinity of Kominato.

I. *Ocynectes maschalis* Jordan and Starks[1]

Syûya Nakamura

(Received Oct. 5th, 1934)

Within easy reach of the warm "Black Current", the south-eastern coast of Prov. Bôsyû abounds with variety of fish eggs and larvae all year round. In residence since May, 1932 at the Kominato Marine Biological Laboratory which is situated on this coast, I have been able to continue field as well as laboratory observations on the ontogeny of many fishes almost without interruption. The present paper is the first intalment of my work on this subject.

Before proceeding any further I beg to record my indebtedness to Professor A. Terao under whose guidance the present work was carried out.

In the neighbourhood of Kominato the adult of a cottoid fish, *Ocynectes maschalis* Jordan and Starks, is found in abundance either in rocky tide-pools or in rock crevices of the shore but not frequently on sandy bottoms. The spawning seems to last from December to April, its height being perhaps in January or February. On January 30, 1933 an egg-mass was found agglutinated on *Sargassum* growing near sea-shore and was transferred to an acquarium for further examination.

1. Embryo.

Eggs are almost spherical and nearly of the same size, each measuring ca. 2 mm in diameter. Beneath the thick chorion the yolk is seen reddish orange in colour in earlier stages (Fig. 1, *A*). The colour changes to yellowish one as development advances, and it is greenish yellow just before hatching (Fig. 1, *B*). A row of stellate melanophores

1) Contributions from the Kominato Marine Biological Laboratory, Bôsyû (No. 1), and from the Zoological Laboratory, Imperial Fisheries Institute, Tokyo (No. 36).

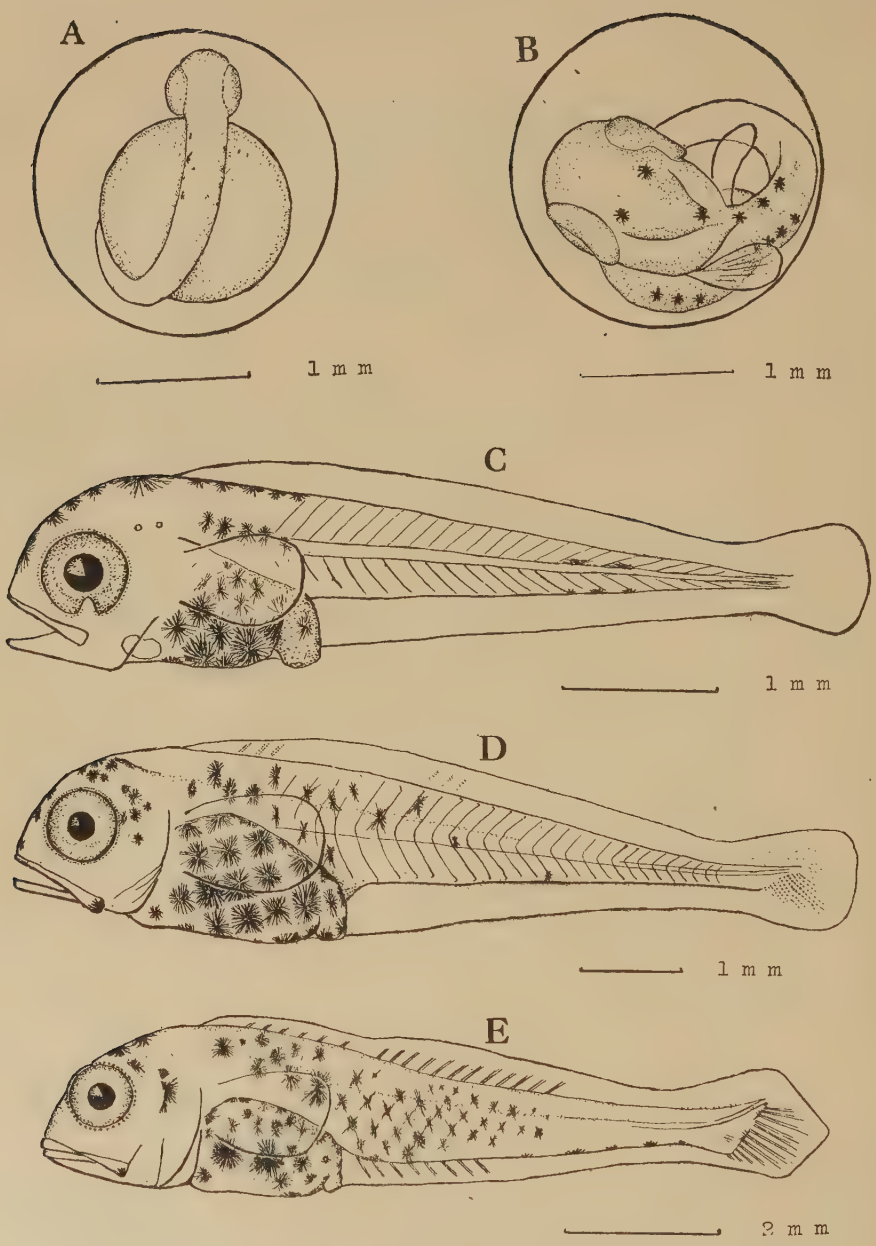


Fig. 1. *A*, earlier embryo; *B*, later embryo; *C*, swimming larva 5.6 mm long; *D*, 8.2 mm long; *E*, 10.3 mm long.

first make their appearance on either side of the dorsal median line of the embryo. The chromatophores of the same kind are then seen scattered on the lateral sides of the trunk of the embryo and also on the yolk sac. At the time the pectoral fin is distinctly formed the head is sparsely beset with melanophores on its dorso-lateral sides.

2. Swimming stage.

The fry leads a swimming life until it attains a length of 14 mm when it suddenly assumes a crawling habit. The smallest fry that I have ever obtained by surface tow is 5.5 mm in length and nearly the same as one measuring 5.6 mm in length which is shown in Fig. 1, *C*. This larva much resembles the embryo which is drawn in Fig. 1, *B* in essential features but is distinguished from it in having a larger number of chromatophores which are mostly found in the anterior one-third of the body. The maxillary extends nearly to the hind margin of the eye, in which the fissure of the optic cup is still distinctly seen. A longitudinal row of melanophores runs along the dorsal median line of the head. The auditory organ is clearly seen through, and almost on the same level with the longitudinal series of melanophores running posteriorly on the lateral side of the body. Below this series large melanophores are somewhat regularly arranged in the form of a fret-work. The myotomes are about 36 pairs in number and overlay straight axial skeleton. The continuous unpaired fin is as yet devoid of embryonic ray and its caudal end is uniformly rounded off.

In a fry of 6.0 mm length, the general outline of the body is almost the same as the above-mentioned one but development of the melanophores is evident not only in the anterior but also in the posterior one-third of the body, several chromatophores being found near the incipient caudal peduncle. Embryonic rays make their appearance in the caudal portion of the unpaired fin.

Fig. 1, *D* represents a larva 8.2 mm long which is characterized by having myotomes 37 pairs in number and axial skeleton very slightly bent near its end. The caudal end of the fin is somewhat truncated and very indistinct embryonic rays are seen besides the much inconspicuous ones in the caudal portion. The maxillary reaches to below the posterior margin of the eye-ball which is now without any trace of the

fissure. The melanophore much increased in number and in range of distribution.

In a larva 10.3 mm in length (Fig. 1, *E*) the upward bending of the axial skeleton near its end is evident, hypural bones being distinctly found in the obtusely angular tail. The dorsal edge of the unpaired fin shows a slight sinuation at the two-fifths of the body. The embryonic rays are now more distinct and numerous. The head, even when the

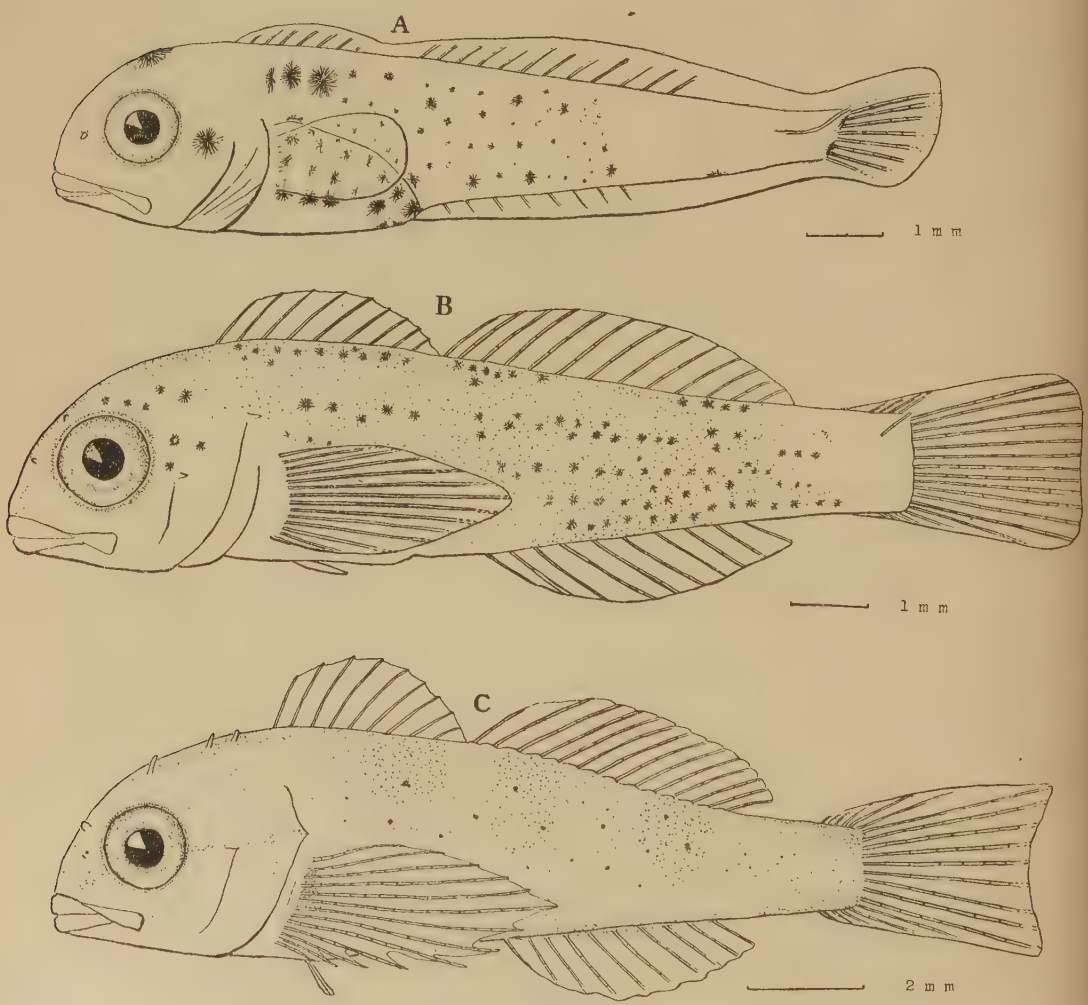


Fig. 2. *A*, 11.7 mm long; *B*, crawling larva 14.3 mm long; *C*, 17.2 mm lhng

total length of the larva is 9.6 mm, is tinted yellowish by the appearance of numerous minute xanthophores. A lozenge-like fashion is seen in the arrangement of the stellate melanophores on the trunk.

The dorsal notch of the fin is much conspicuous in a larva 11.7 mm long (Fig. 2, *A*). The definitive fin-rays are laid down in the caudal, upper half of which is longer than the lower. The ground colour of the body from head to tail is now transparent yellow. The differentiation of the melanophores into larger and smaller types is apparent, regularity of their arrangement being lost to a degree.

Intermediate between the two stages shown in Fig. 2, *A* and *B* is one measuring 13.0 mm in length. In this larva the first dorsal with nine spines and the second dorsal with 13 rays are distinctly separated. The anal with 10 rays is apart from the caudal. The ventrals are clearly seen. The pectoral has an acute end. The ground colour of the body is yellowish green, profusely covered with very minute melanophores and sparsely beset with larger stellate melanophores.

3. Crawling stage.

The change of the habit from swimming to crawling is observable in a larva 14.3 mm long (Fig. 2, *B*) when kept in an acquarium. Three pairs of dermal papillae make their appearance on the head, and a feeble spinule on the preopercle. The eye is much enlarged and its hind border reaches beyond the maxillary. The lower half of the caudal is as long as the upper. The ground colour of the body is yellowish green, tinted faintly black. Larger melanophores are arranged in several longitudinal series.

In a larva 15.9 mm long, the ground colour of the body is greenish. Four faintly black bands cross the body ventrad from the dorsal median line, viz., each two below the first and second dorsals. Of these, the first cross band is the faintest of all.

Fig. 2, *C* represents a 17.2 mm long larva in which the above-mentioned four cross bands are better made out. In addition to these a rather well-defined longitudinal black stripe runs posterad from the upper lip to the hind edge of the opercle, and this stripe marks lower white half of the head. Otherwise, the ground of the body is greenish in colour. The caudal is slightly emarginate at its end.

In a much advanced larva which is 27.5 mm long (Fig. 3, *A*) the general outline of the body much resembles that of the adult. In this

larva the fifth cross band appears in the caudal peduncle but deformation of other bands already sets in. The ground colour of the body is now greenish brown. The eye is much enlarged, surpassing the maxillary by half its diameter. Of elongated dermal papillae on the head, the supra-ocular one begins to branch. The rays of the much expanded pectoral are provided with dark brown blotches. The extension of the ventrals is also remarkable, not to mention elongation of the anal and dorsals.

At the time the fish attains a length of 30.0 mm. (Fig. 3, *B*) the five cross bands are disintegrated into an irregular vermiculated pattern. Around the series of the lateral-line organs the melanophores are mostly absent. Several black patterns appear on the top of head, cheek, preopercle, and opercle. The ground colour of the body is brown tinted with blue, and it is fainter toward the ventral side which is almost white.

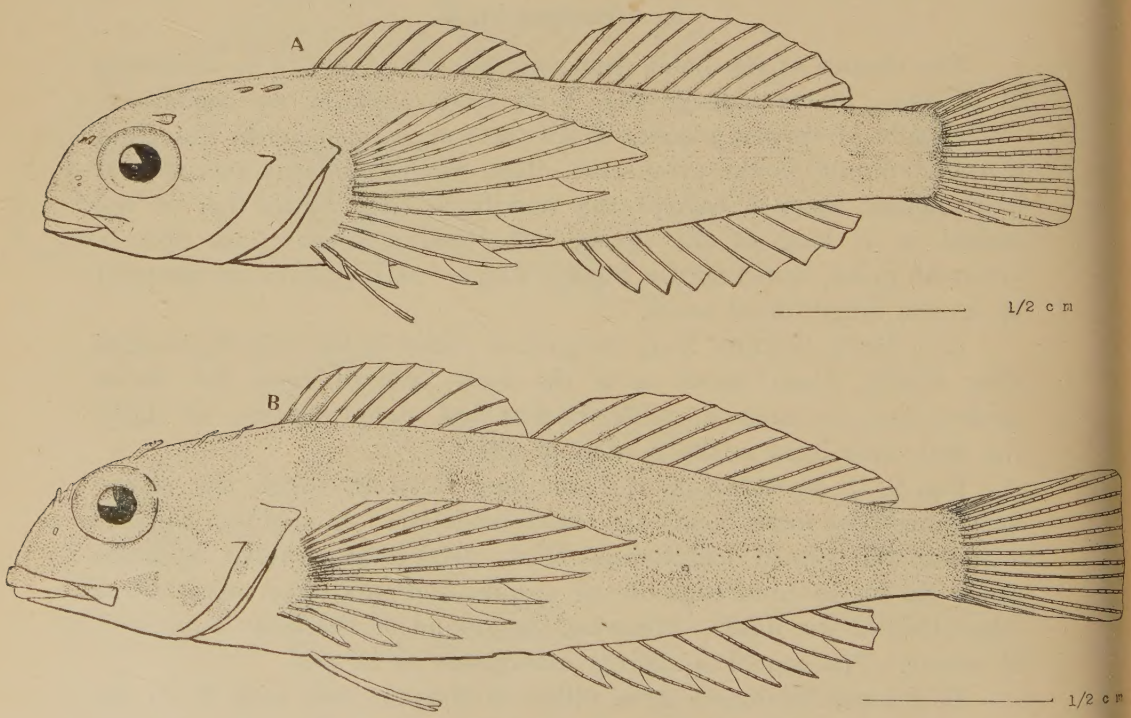


Fig. 3. *A*, 27.5 mm long; *B*, 30.0 mm long.

A young 36.5 mm long is nearly the same as the adult in general shape of the body and in having black patterns on the dorsal, caudal, and anal fins as well. The ventral side of the bydy is faintly bluish green in this stage.

4. Comparisons with other forms.

Our knowledge of the larval development of the fishes of the family Cottidae is too meagre to warrant us any phylogenetic generalization of the group in question. But I would like to say that *Ocynectes maschalis* is closely allied to the fishes of the genus *Cottus* in the development and arrangement of the melanophores and in later appearance of fin rays. In view of the ontogeny it appears that *Gymnocanthus ventralis*, *Centridermichthys hamatus*, and *Triglops pingeli* are rather widely separated from one another and from *Ocynectes maschalis* although they all belong to the same family.

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